

FOOD SECURITY AND SMALL-SCALE AQUAPONICS: A CASE STUDY ON THE
NORTHERN MARIANA ISLAND OF ROTA

by

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A THESIS

Presented to the Department of International Studies
and the Graduate School of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Master of Arts

December 2014

THESIS APPROVAL PAGE

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Title: Food Security and Small-Scale Aquaponics: A Case Study on the Northern Mariana Island of Rota

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Degree awarded December 2014

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THESIS ABSTRACT

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Master of Arts

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December 2014

Title: Food Security and Small-Scale Aquaponics: A Case Study on the Northern Mariana Island of Rota

Aquaponics has recently emerged on the global scene as a viable form of alternative agriculture. A combination of practices, such as growing and harvesting fish (aquaculture) along with “hydroponically” grown fruits and vegetables, aquaponics integrates traditional agriculture practices with twenty-first century scientific food producing methods. In this thesis, I analyze the literature on aquaponics and connect it firmly within the current social and environmental discussions of the food security discourse among Pacific Island Countries and Territories in order to provide a context of geographical relevance of fish and vegetable producing systems. I also provide data from the Northern Mariana Island of Rota to showcase why and how aquaponics may be a viable option for improving food security within such a context. I then argue that the aquaponic project on the island of Rota helps serve as one potential pathway to improving food security.

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ACKNOWLEDGMENTS

I would like to express my gratitude to my loving wife Camille and children Caroline, Cecilia and Christian for all of their support and understanding during the course of this most challenging endeavor. I am most appreciative of Elizabeth Weiser who made this thesis logically coherent with her superior editing skills. I want to say thank you to the Songao and Atalig families who welcomed me into their homes and community and shared with me the cultural richness of the Rota people. Specifically, David, Diego, Frnak and Antonia, I hope to see you all soon! Frank, my experience on the island with you will be treasured for the rest of my days. To my family the Fosketts: We did it! Nick and Steph I love you both. Aunt Kim, Kris and Kathey thank you for all of your love and emotional support throughout this entire process. Uncle Kevin, you are a beacon of strength and a guidepost of dignity for me and to my children. You have shown me what it means to be a Foskett and a man. Press On!

For Papa. This one is for you! Always in remembrance of Grandma Mar, my mom
and dad, Keith and Carol.

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CHAPTER I

INTRODUCTION

Why are we doing aquaponics here on Rota? That's easy; food security."

*--- Francisco (Frank) Atalig, Rota municipal treasurer and Aquaponic Education
and Learning Center Grant Manager*

In September 2012 the mayor of the Northern Mariana Island of Rota, Melchor Mendiola, signed the project receipt for its locally controlled and implemented aquaponic food security project. At a prima facie level one would not understand the imperative of food security on such a majestic and welcoming little island deep in the Pacific Ocean. Rota, a part of the Northern Mariana Islands, is a territory of the United States. There, abundance takes the back seat only to the local hospitality and charm of a very small, yet tight-knit community. Looking around one sees coconut in almost every corner and backyard of the island. Bananas, coconut crabs, Pilipino samba deer, and fruit bats—all of these abound among rare birds unknown to any other place in the world. An ocean shoreline that welcomes the local fisherman to catch such diversity that one can experience the richness of the Pacific in a matter of days when dining among the locals. Why, then, do the local government and members of the community consider Rota to be in a “state of emergency” because their food security is threatened? Why are they interested in promoting aquaponics on the island, how are they doing it, and how can aquaponics contribute to improving food security on Rota? The Rota aquaponic project is an outgrowth of a complex history and political relationship with the United States whereby Rota, became a post-war addition to its commonwealths and territories. The

project carries with it both implicit and explicit implications and notions that are most certainly a response to a presently globalized and ever globalizing world. With global income disparity on the rise and lack of accessibility to fundamental life-giving resources such as water, energy, and healthy food, coupled with issues such as climate change, resource depletion and external dependency for Pacific Island Commonwealths and Territories (PICTs), understanding alternative food security initiatives aimed at achieving community well-being, environmental sustainability, and food sovereignty such as the one undertaken by the municipal government of Rota is crucial.

Situating Rota: Cultural Background and History

The chain of tiny islands known as the Commonwealth of the Northern Mariana Islands (CNMI) has a long history of global geopolitical significance (CIA World Factbook 2001, Dept. of Wasington). The history of Rota, like that of the rest of the islands within the Mariana Archipelago, consists of multiple periods of colonization, religious conversion, and cultural conquest (Hezel 1989, Emerick 1958, Driver 1990). Rota has experienced foreign control and influence from Spanish conquest, German and Japanese occupations, and now as a U.S. “Trust Territory” patrolled by the U.S. Navy after WWII. It was not until 1978 that Rota started to take control of its political and civil order (Emerick 1958). This history has consisted of multiple resettlements of the local population, which has unsettled traditional and contemporary agricultural practices. Its recent history has been made up of certain economic and political initiatives that have sought to move the people of Rota into a state of land and home ownership and agricultural empowerment. The aquaponic project is thus locally motivated as a means to

bring agricultural independence to the local people in light of these historical consequences.

Beginning with Magellan's visit in 1521, the Mariana Islands have had a history of colonization, trade, and religious conversion which would continue for the next four and half centuries. This was due to the fact that the Spanish which had settled New Spain or Mexico travelled across the Pacific in order to bring their riches back to Europe. However, the missionaries as many of them were, needed to barter for water and food if they were to make all the way back to their homeland. The islands were immediately recognized as at a strategic location for the crossing of the Pacific between the two worlds as it fueled what has been called the "galleon trade" where the Spanish found the necessary supplies for the voyage home. (Driver 1990). Over the course of this history the local inhabitants experienced not only forced resettlements, battles, epidemics and emigration, but religious conversions to the Catholic faith as well (Driver 1990; Ibanez y Garcia 1992). All of which have affected the population and local Chamorro culture which still exists today.

Missionary records indicate there were roughly 100,000 people living on the Mariana Islands in 1668 (Fritz 1986). During the time of the Spanish influence, from 1564 to 1898, there were many events which disrupted the local Rota population. The 16th and 18th centuries consisted of forced resettlements where the Spanish sought to depopulate almost every island in an effort to concentrate the locals into a few towns on Guam which almost resulted in the complete genocide of the peoples of the Northern Mariana Islands (CNMI HistoryGuide). While all islands in the Marianas were eventually subdued, natives on Rota, unlike Tinian and Saipan, were able to escape this

effort by withdrawing into the jungle. Thus, Rota has had continuous Chamorro settlement and today remains the most “Chamorro” of all the islands (Emerick ,1958). This means that while the impacts of colonization had detrimental effects among the Mariana Islands, it was not able to completely erase the Chamorro identity and culture. The results of this forced resettlement, as in much of American history, were famines and epidemics which nearly wiped out the entire Mariana population. It was within these time periods that the Carolinians, who presently make up another indigenous segment of the population, began to migrate to the Marianas. This period in history also consists of some uprisings and local resistance to religious conversions that ended in Spanish dominance over the island. In 1710, there were only 3,678 native Chamorros, and by the end of the 18th century, a mere 1,639 remained (Fritz: 8).

The 19th century has a detailed history of epidemics which affected the population of much of Rota. Documents from the 1800s discuss six different periods of smallpox and fevers that affected all age ranges of the population, though none was as severe as in the early 19th century. By the end of the 19th century, the Germans had taken control of the island (Fritz). This is significant because they took census records, which help to serve as a social indicator of how much of an impact these illnesses had on the population. These records indicate that in 1887 there was a total population of “9,680 natives”, and by 1902 there were a mere 2,401 (with the exclusion of Guam) (Fritz : 8). Thus much of the colonial era consisted of having a depopulation effect on the locals of the Marianas.

The early 20th century saw the Japanese takeover of the Marianas as part of a deal help between the League of Nations when the Germans were forced to cede foreign

control and sell Guam territory to the U.S. during the pre-WWI period (CNMIHistoryguide). During the time of the Japanese occupation, the people of Rota were moved from the agricultural village of Songsong to a less fertile area of the island known as Tatacho. The 1930s involved the relocation of the Rotanese from one portion of the island to the other, such that locals lost traditional and public domain over their land as well. The Japanese quickly moved to the production of sugarcane, whereby many of the locals were used as a form of slave labor (Emerick 1958). The Japanese built housing for the workers and forced the locals into the production of sugar as the main economic driver of the islands. The Japanese also heavily populated the islands, and estimates range from 40,000 to 45,000, with only 4,000 Chamorros documented during this time.

Guam and the Northern Mariana Islands fought alongside America in resistance to Japanese occupation and took back control of the islands during WWII. After the war, the Mariana Islands became a “Trust Territory” under the protection of the United States Navy (Emerick 1958 found in “Land Tenure Patterns”, CNMI Historyguide). It was not until 1978 that the Northern Mariana Islands became officially and voluntarily a commonwealth of the U.S., hence the contemporary name the Commonwealth of the Northern Mariana Islands, or CNMI (CIA World Factbook, 2008, Pedro Tenorio,2006). During this postwar period and up until the end of the twentieth century, the islands experienced a steady increase in both population and economic activity. The latter half of the twentieth century were some of the best years economically experienced on the island since the colonial era (Pedro Tenorio, 2006). This is because of high economic prosperity where per capita gross island product “quadrupled from \$2,500-\$10,000”

during the years between 1980 and 1997 (Bolick 1997). It was also during this time that the people of Rota were offered plots of land and were given the option to build a home in the Sinapalo village if so desired. This policy even had the effect of bringing some Rotans back to the island that had previously left. While it was intended to bring members of the community back into close proximity to each other, there have been issues raised concerning the location of the village. As will be mentioned later, the location of the village is problematic when discussing access to agricultural resources. This discursively leads us to question how the location of the village was determined and why. While these questions are not incorporated into the scope of this work these questions are important to ask when considering any discussion on food security.

The Twenty-First Century and Rota

In the late 1990s, an international trade deal between the U.S. and China stalled Rota's economic growth. In 1999 the U.S. made an international trade deal that impeded the Mariana Island's ability to compete in the garment industry, as U.S. tariffs within the textile industry were reduced and China became the main competitor in the industry (CNMI Congressional Records 2006). While not catastrophic to the U.S. mainland economy, this deal has had detrimental effects on foreign and territorial economies (Hoover Institution Study 2000). This was especially true in Rota, as the garment industry, which consisted of over 95% of the island's entire export industry, was lost. From 34 garment factories in the CNMI before the trade agreement, Rota now has none. This loss was then coupled with the 9/11 attacks on the World Trade Center and the subsequent War on Terror, leading to a reduction in Asian and American tourism and

creating a further devastating blow to the local economy (CNMI Congressional Records 2006).

Combined, tourism and textiles had accounted for over 80% of the island's employment, 85% of all economic activity, and a generous tax base (Gao.gov.). In 1990, the CNMI's General Fund Revenues sat at \$116.7 million. The peak of CNMI economic activity brought in a revenue base of an impressive \$248 million. However, by 2006 the CNMI government had a deficit exceeding \$100 million (Tenorio, 2006).

The social impact of this economic downturn is exemplified in the increase of families on government assistance and on the total number of community members living below the poverty line. In 1992 there were a mere 565 families enrolled in the Nutrition Assistance Program(a food stamp program); in 2005, there were 2,276. These numbers indicate a whopping 303% increase in people who are now in need of additional food and nutrition and do not have the ability to acquire it themselves (Tenorio 2006). Those living below the poverty line increased 8.5% from 1999 to 2005, rising from 46% to 53.5% (GAO.gov). While these number may not be as alarming as those which represent the number of families living on government subsidies, what it does show is that poverty increased as well.

Due to the lack of available jobs and lack of interest in traditional forms of agriculture (working and harvesting food from the fields), the younger generation feels as though it has only one of two options: they can either leave the island in hopes of finding other opportunities or they can stay dependent on government subsidies with no real opportunity for economic advancement (Atalig Interview). Because of this, many of the younger people on the island have left, and Rota in the twenty-first century is

experiencing population flight for the first time since the post-war period (U.S. Census Bureau, 2010, U.S. Census Bureau, 2000). The increase of those dependent on government assistance for food and the decline in population among the younger generation is a concern for Rota's municipal government, and it leaves them with the charge of asking "what do we do now?"

While Rota is surrounded by beauty and the resources to produce its own food, this economic hardship which plagues the majority of the population prevents most from acquiring access to these resources. Previous projects to improve localized food production among the people have failed (to be discussed later) due to the environmental laws put into place to protect the pristine environment on Rota and due to location of village settlement that is distant from Rota's fertile lands. These laws, local concerns within the municipal government, and overall community have led to the desire to approach food security from an environmentally sustainable perspective. It is within this twenty-first century context that the municipal government of Rota is trying to improve its own food security through the production of small-scale aquaponic food systems.

The Scope and Purpose of This Thesis

This thesis focuses on the following central research questions: First, Why has Rota chosen aquaponics as a method to enhance its own food security? Second, How does aquaponics attempt to address food security on a Pacific island territory such as Rota? When considered in a more holistic context that encompasses economic, social and environmental dimensions of sustainable agriculture, aquaponics attempts to fulfill a multifaceted void within the practice of food security among Pacific Island Countries and Territories (PICTs). This thesis on Rota and its food security initiative of aquaponic

production addresses this void by putting forward the following case study as a model for future initiatives for similarly dependent and isolated states. It is here that I wish to contribute to the literature on food security among PICTs.

This thesis comes from over a year and a half of research both theoretical and empirical, including field research on the island of Rota studying an alternative agricultural system that is one of the most progressive and cutting edge manifestations yet of social responses to failed food security initiatives over the course of the last 65-70 years. When considering how or through what means food security is achieved today, I will in the first section first interact with the literature of sustainable agriculture and agroecology, and then introduce aquaponics as a valid form of sustainable agriculture and as a subset of agroecology. In the second section, I will focus specifically on a case study of the current aquaponic project on Rota, examining the project from the perspectives of government officials, aquaponics specialists, and the general community. My aim is to demonstrate the Rota aquaponic project as one potentially viable mode of food production for improving food security in a number of ways. More specifically, as it is attempting to improve its own food security through aquaponic food production, Rota is also trying to address social, environmental and economic factors that are necessary for food security, and it is doing so by means of community outreach and aquaponic education.

CHAPTER II

FOOD SECURITY AND AN AQUAPONIC RESEARCH STUDY

Food Security

What is food security? There are literally hundreds of definitions (Pointing, Smith and Maxwell 1993), Lang and Barling 2012) and one might find close to “20 million hits on the web” (Carolan 2013: 1). As Edward Carr notes in his description on the evolution of the term this is because “food security is a dynamic idea that has undergone significant transformations in its conceptual lifetime.” (2006: 15). The definitions of food security have evolved as a response to failures to solve the global problems of hunger, increased food crises, and as social movements try to redefine what the concept means to them. The methods introduced in this work argue for sustainable agriculture and agroecological principles which represent some of the most current scholarship on food security terminology and concepts. This will aid in understanding why aquaponics has become the more favored method of food production on Rota.

Post War Period and State-Led Production

While scholars have traced the roots and dominance of the global trade in food or “food regimes” to the 19th century and beyond (Fairbairn 2008), some scholars have attributed the original spirit of what we know today as food security to the early 1940s (Carolan 2013). Carolan states that President Franklin Roosevelt’s 1941 State of the Union Address, where he identified “four essential freedoms” which are shared everywhere in the world was the context from which the food security movement began (Carolan 2013). Two of these four freedoms state “freedom from want” and the

“freedom of fear.” took the charge “to consider the goal of freedom from want in relation to food and agriculture” (CFS 2012/39/4 ; Carolan 2013: 16).

Five years later the United Nations would expand these concepts with the “right to food” enacted in the Universal Declaration of Human Rights (UDHR) (Fairbairn 2008). These ideas of freedom from want and the right to food helped engender public support for the “Green Revolution,” which reputedly sought to solve food insecurity by increasing the supply of food on a global scale by producing High Yield Variety (HYVs) seeds on a macro scale. (Carolan 2013: 17; Robbins 2011). While high in production, such seeds have also been called Energy Intensive Varieties due to the high level of chemical inputs and water that is needed to sustain them (Robbins). And with lots of other inputs (fertilizers, pesticides, machinery, agricultural extension etc)

During the Cold War it was important for the United States to prove to the world that capitalism promised to bring freedom and prosperity to the world. After the passage of Public Law 480, the U.S. was free to subsidize the agricultural sector and distribute grain surpluses to the developing states all over the world. The U.S. now had the financial and technological capabilities to produce and distribute food at rates never before seen in the world. However, such grain distribution in the name of prosperity has been argued to have had the opposite effect. As Fairbairn states, this “ingenious arrangement... served the dual purpose of winning allies in the Global South during the Cold War and disposing of surpluses in such a way as to cause dependency and create future markets for those grains.” (Fairbairn 2008: 17). In retrospect, the production of food in the form of food aid had catastrophic impacts on the developing nations as it stifled indigenous markets and their ability to compete. (Carolan 2013).

Such negative impacts on the developing world (non-western nor industrialized states) eventually saw the collapse of the State-led “post-war food regime.” It was then not long after that the first rounds of food security definitions began to emerge, as a response to a shortage of wheat production in the Soviet Union. The U.S. under President Richard Nixon had sold the U.S.S.R. some 30 million metric tons of grain, which helped spur the world food crisis of 1972-1973. In response to this crisis, the UN held a World Food Conference in 1974 where the first use of the phrase “food security” is recorded:

The well-being of the peoples of the world largely depends on the adequate production and distribution of food as well as the establishment of a world food security system which would ensure adequate availability of, and reasonable prices for food at all times, irrespective of periodic fluctuations and vagaries of weather and free of political and economic pressures, and should thus facilitate, amongst other things, the development process of developing countries (UN 1974).

Scholars have acknowledged that while this paragraph mentions food security and the well-being of peoples around the world, it proved to be problematic as it still viewed hunger from a Food Availability Decline (FAD) perspective, meaning that hunger was due to a nation’s inability to *produce* and it was the lack of supply which was the culprit of such hunger (Maxwell 1996). This point became more poignant a year later when in 1975 the UN issued its final report on the world food crisis of 1972-73 and the first definition of food security emerged as “availability at all times of adequate world supplies of basic food-stuffs..., to sustain a steady expansion of food consumption..., and to

offset fluctuations in production and prices (UN 1975 found in Maxwell 1996: 156).

Here several important factors can be inferred: food security was first framed by national and international actors, it focused on supply or the production of food as the solution and it sought to achieve this through global agricultural policies. Food Security also “has its roots in a global-scale concern for food supplies manageable via macro-economic agricultural policies. These efforts focused on the supply of food as “*the determining variable*” (author’s emphasis) for food security.” (Carr 16: 2006). It would not be until the early 1980s that food security would begin to shift from an emphasis on production to a more complex understanding of access and entitlements.

Amartya Sen is credited in his work *Poverty and Famines* 1981 with changing the focus from food availability to food *access* in order to achieve food security (Maxwell 1996, Fairbairn 2008, Maxx Dilley and Tanya E. Boudreau 2001) through a focus on individual and household access to food. Sen argued that access or lack thereof was due to certain “entitlements” which created what he called “effective demand.” Particularly, effective demand means the ability to purchase the food which was available or the lack thereof. It was because certain individuals had effective demand, which determined whether they would starve or not, and it was this argument that could explain why some people went hungry in largely populated cities like Bengal and others within the same locale did not (Sen 1981). Sen’s ability to shift the focus from availability to access is evident in the World Bank’s 1986 report of *Poverty and Hunger*, where a new definition, still prominent today, states food security as “Access by all people at all times to enough food for an active and healthy life.” We can see even further implications of his work in The World Food Summit of 1996 definition of food security, which states “when all

people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life.” (FAO 1996, WHO.org website).

While scholars admit to the influence Sen’s argument had on shifting the focus of the debate from hunger being attributable from natural hazards to “access issues [that] are entrenched in social, political and economic relations” (Dilley and Boudreau 233: 2001), more current scholars acknowledge this as supportive of the “neoliberal approach” to addressing food security. This is because of its emphasis on the individual, increasing market access, and the minimal role of the state, which are inherent concepts of neoliberal ideology (Fairbairn; Carolan 2013). This new emphasis on individuals and access helped spur the neoliberal era of food security which began with a new round of food security initiatives, a whole new set of definitions and does not come without a whole host of academic and social critique.

Even though neoliberalism began to emerge in the 1970s, food security scholars generally acknowledge that this “shift in the site of food security from the nation-state to the world market was engineered during the Uruguay Round (1986-1994) of the World Trade Organization (WTO) negotiations” (Fairbairn 2010). It was after these rounds that the infamous liberal trade agreements such as the North American Free Trade Agreement (NAFTA)) began to emerge. This approach of opening borders and reducing barriers to trade was originally argued as the solution to hunger and poverty, but it has also been argued by scholars to have created wide-spread social instability and massive food insecurity. While the claims as to *how* neoliberal economics have impacted societies are controversial and varied, it has been well documented as to what types of responses have been borne out of such policies. In response to these top-down economic policies, social

movements were formed which challenged the role of the State and transnational corporate actors in order to *redefine* what food security is and how it should be achieved. Culminating with the “food sovereignty” concept which argues for agroecology and sustainable agriculture as a means of how countries improve food security. This is important as it exemplifies a contemporary understanding as to what local and grassroots communities mean when they argue for food security. This is also important for the Rota case study in that it provides a theoretical and practical foundation for the aquaponic project within the food security literature to which I hope to contribute.

Trade liberalization (the reduction of barriers to international trade and the “reduced” role of the state to regulate such trade) was and is still today championed as an economic policy which will open the doors of production and increase wealth for all nations involved, but despite its efforts to promote the agricultural sector and economic prosperity, trade liberalization has actually increased food insecurity around the world because of its ability to knock local competitors out of the market (Bello and Baviera, found in Wiebe, Wittman and Desmarais, 2010).

In response to neoliberal policies and the “corporate led model” of agriculture, social movements emerged all over the world in order to redefine and expand the meaning of food security. Coming from the perspective of peasants and farmers and grassroots organizations around the world, the evolving definition has expanded to a new concept known as food sovereignty (McMichael, found in Wittman, Desmarais, and Wiebe 2010).

One of the basic tenets of food sovereignty is to afford the right for those who *produce* the food to *consume* the food (Patel 2002). The food that is produced must also

be safe and healthy for such consumption. This emphasis on health and safety, is in response to the methods of global food production that consist of GMOs, high calories and low-nutrient food which threaten the health and well-being of the hungry and thus have been argued to actually produce food insecurity, not reduce it (Carolan 2013). Another tenet of food sovereignty is the concept of environmental sustainability and local control/management of aquatic resources for fishing communities. This can be seen, for instance, in this definition from the People's Food Sovereignty Network:

Food sovereignty is the right of peoples to define their own food and agriculture; to protect and regulate domestic agricultural production and trade in order to achieve *sustainable development* objectives; to determine the extent to which they want to be self-reliant; to restrict the dumping of products in their markets; and *to provide local fisheries-based communities* the priority in managing the use of and the rights to *aquatic resources*. Food sovereignty does not negate trade, but rather, it promotes the formulation of trade policies and practices that serve the rights of peoples to safe, healthy *and ecologically sustainable production*.

(2002:1, Found in Patel's What Does Food Sovereignty Look Like?)

This quote is important because it not only defines food sovereignty, it also highlights key aspects of how this might be attained. The food sovereignty movement advocates local control and sustainable development practices *in order to achieve* real food security. This is also shown in La Via Campesina's 1996 definition of food sovereignty, where "Food sovereignty is a precondition to genuine food security." (Patel 2002). It becomes apparent, then, that food sovereignty is a precondition of food security consisting of local and ecological management (social and environmentally integrated components) which is not defined by national and international actors but by the people who are producing the food.

Food Security in the 21st Century

The twenty-first century seems to be about redefining and reinterpreting what food security is and what it means for people and nations. This can be seen in the works of “Reclaiming Food Security” by Michael Carolan, “The Feeding of Nations: Redefining Food Security For the 21st Century” by Mark Gibson, *Food Security and Food Sustainability: Reformulating the Debate* by Lang and Barling and *Postmodern Conceptualizations, Modernist Applications: Rethinking the Role of Society in Food security* by Edward Carr. Most of these arguments, which are highly critical of the development decades of the twentieth century, would prefer to not only move the conversation away from definitional arguments for food security, but also expand the notion by focusing on the concepts of what have been named the “four pillars” of food security (Carolan 2013; Gibson 2014).

Coming out of the World Food Summit of 1996 was the integration of many competing ideas of food security into a conceptual structure now known as the “four pillars” of access, availability, stability and utilization in achieving food security (FAO.org, WHO.org, UN.org). These pillars represent a convergence of concepts over the past few decades concerning food security. The pillars also illustrate a move away from the attempt to define food security and instead to understand what food security consists of from a fundamentally social and environmental perspective (Gibson2014).

Access refers to the ability of “physical and economic” attainment of food, availability suggests “food in sufficient amounts to meet people’s needs,” (Rocha 2008) and utilization acknowledges the importance of nutrition, safety and diet quality (Gibson 2014, UNICEF report). Not excluding the importance of economic benefits within the

pillar of access, scholars have interpreted it to entail “the adequate integration and functioning of both local and international markets to effectively supply the food.” (Gibson. 9: 2014). Even the food sovereignty ideology held by La Via Campesina stresses the importance of markets: “Food sovereignty prioritizes *local and national economies and markets* and empowers peasant and family farmer-driven agriculture, *artisanal fishing*, pastoralist-led grazing, and food production, distribution.” (Nyeleni Declaration found in Patel). La Via Campesina goes on to make the point that this must be “based on environmental, social and economic sustainability” (Patel). The emphasis on markets based on environmental, social and economic sustainability ties into the a comprehensive framework of how the Rota project is intended to not only provide a method of producing food, but to also provide incentive for entering into a local market of vegetable and fish production. This will be further elaborated upon during the findings portion of the research.

The third pillar, stability, discusses the “environment surrounding those of the other pillars of access, availability, and utilization” (Gibson : 493, 2014). Instability is anything which threatens the previous three pillars and stability is an effort to prevent such occurrence. This is generally sought by focusing on political and economic dimensions. Political stability focuses on the support of democratic governance as it generally creates “social support” and “livelihood protection programs.” Democratic governance nurtures stability in that these support structures tend to stay intact regardless of who comes and goes into positions of power (Gibson 2014). We shall see that this is a concern for the Rota project.

What current scholars have discussed when considering these pillars is that food security is “culturally specific” (Gibson 2012: 9) and is “best understood... on socially-conditioned local knowledge and perceptions of those conditions.” (Carr : 15). Food security is more of a process than something that one can look to and identify (Carolan 2013) and is “beset with... competing ideologies, of disagreement and a constantly evolving remit.” (Gibson : 494). These arguments have led recent scholarship to conclude that the core task of the 21st century is “to create a sustainable food system.” (Lang and Barling 2012) and avoid concrete definitions which run the risk of stagnating a fluid concept. This is important to understand in that food security projects need not have a set definition but that they are allowed to fit a conceptual framework that can evolve according to the context from which it is applied.

In dialogue with the idea of sustainable food systems it has been argued that sustainable food supplies are a means to an end, and in order to understand food security there must be a focus on local systems of power and knowledge and how it plays a role in the process. . It is also agreed that sustainable food systems must provide environmental, social and economic benefits which contribute to the overall well-being of the local community employing such practices (Carr 2006). In sum, the process of food security consists of an environmentally sustainable food system that is culturally and geographically specific upholding the “four pillars” in an effort to promote local production for local consumption, and thus provide social, economic, and environmental benefits to the communities that employ such a framework. This understanding of food security is where I will further tie in the physical and theoretical goals of the Rota aquaponic project so as to make it relevant to contemporary food security literature.

Current Discourse on Food Insecurity for PICTs

Islands in the Pacific receive a high proportion of their animal protein directly from coastal fisheries and marine life (HLPE Report #7, 2014). Over the course of the last three decades PICTs have seen the commercialization of such fisheries from which many of their economies now depend. This literature reveals that climate change, dependency on imports, and socioeconomic development due to commercialized fish economies all effect food security in the region (Kittinger 2013). It has been argued that aquaculture is a necessary component for improving food security, especially for PICTs (Bell, Kronen et. al. 2009). This concept is not without critique however, in that aquaculture still needs study in that it can be too expensive for the poorest sectors of society, can be harmful to the environment, can contribute to fish depletion (HLPE Report #7, 2014), and can have devastating effects on the health of communities that live near areas of aquaculture production (Weinberg 1996). It has also been publicly critiqued for its inability to address very serious oceanic concerns of overfishing and marine life pollution (NYTimes 2005). These negative effects have been experienced world-wide including Latin America, the Mediterranean, and Southeast Asia (Wienberg 1996). In response to these effects it has been concluded that “freshwater tilapia aquaculture have therefore been identified as options to increase local fish supply.” (HLPE Report #7 2014) This means that in order to preserve the coastal fisheries freshwater fish production becomes ever more relevant to PICTs. It is here, that I stress the significant role that Rota can play by providing an alternative mode of food production that addresses the critiques of aquaculture through the aquaponic initiative.

Threats to Food Security in Pacific Island Countries and Territories

The World Bank has concluded that climate change will affect the PICTs in three major ways: increased natural disasters in the form of cyclones and typhoons, a rise in sea levels, and increased water temperatures (FAO 2008). Within these three factors, scholars have documented both observable and projected impacts that climate change has already had/will have on food security for the Pacific countries and territories.

Projected impacts of increased natural disasters consist of land destruction, increased salinity in soil and the loss of coral reefs due to rising temperatures in the ocean. Because of the increase in storm surges there is projected to be coastal erosion, which will affect the infrastructure of many of these islands (FAO 2008) This can contribute to the displacement of people from one region to another on the islands (HLPE 2014). Increased salinity in the soil means that many of the traditional crops, such as taro, will be highly threatened. This is a concern in that taro is a traditional crop to many Pacific islands. With the increase in water temperatures comes the very real threat to the coral habitat (Secretariat of the Pacific Community 2011). Rising temperatures in the ocean can play a significant role in the destruction on coral reefs. Coral is a very fragile ecosystem which houses a multitude of marine species and any subtle changes in temperature or malpractice of fish harvesting practices can threaten the survivability of such a system upon which most of the Pacific islands depend for food (HLPE 2014). These changes in land and environment would have a major role in daily cultural practices and livelihoods in the region.

Climate change has already made very real and observable impacts for many of the countries and territories in the Pacific, including multi-decadal long warming of air and water (secretariat of the Pacific Community 2011). The Southern Pacific is becoming “drier,” while the central Pacific is experiencing both increased rainfall and severe droughts. These conditions mean increased natural disasters such as typhoons and rising sea levels, all of which contribute to food insecurity. The increase in severe weather conditions not only affect crop production on the islands, but has limited their ability to import food that has been needed at times to prevent famine (Secretariat of the Pacific Community 2011). These impacts highlight not only the vulnerability of these islands to severe weather conditions but also their dependency on food imports from the external world and will be elaborated upon in the case study offered below.

There are numerous direct and indirect socio-cultural and environmental implications to the observable and projected impacts of Climate Change for PICT’s food security. Some of these include the increased prices of imported food, changes in the patterns of fish migration, loss of agricultural productivity especially for the poorest of the populations, and increased health risks due to the lack of nutritional food (Ibid.). All of these impacts threaten the sustainability of food production and cultural traditions. There is literature which discusses how some Pacific islands may benefit from changes in fish migration due to the warming of the Pacific. This literature reveals that Western islands may experience a decline in tuna populations while migrations will increase the harvest in the more eastern islands (Bell et. al. 2013). Increased and negative sociocultural impacts from climate change will demand changes in how food is grown

and harvested if food security and well-being of these communities is to be achieved (Bell et. al. 2013).

The importation of staple crops has had considerable negative consequences on the health of the populations of the Pacific islands (ACIAR.gov). This has to do with two main factors: what type of food is being imported and what regulations, if any, are being implemented during the transportation phases of the food. Studies done over the course of the last decade show Pacific Islanders have some of the highest rates in the world of diabetes, heart disease, and obesity.(Secretariat of the Pacific Community 2011, FAO 2014) While the food is generally cheaper, it is also much more energy dense, contains more fat, has a higher sodium content and is essentially without vitamins A or C (Ibid). Studies have also shown that negative health issues have resulted in the lack of proper regulation and handling of food upon transport and arrival into the islands. Some of the food has been exposed to warmer temperatures than it should be and has been sold after due dates. This has contributed to diarrheal and parasitic infections (Ibid.).

Imported food not only has a negative impact on the health of those consuming it but it likewise upsets traditional practices of growing and harvesting food. This also has negative impacts on the population as many lack proper exercise and become accustomed to a more sedentary lifestyle (Ibid, FAO.org 2014). The fact that these foods are sold at a cheaper cost makes it impossible for local farmers to compete, in part because “semi-subsistence producers are too poor to buy the modern farm inputs.”(FAO.org 2014) This results in the loss of traditional farming land, loss of local production and an increase in urbanization or the consolidation of people into villages or town centers (IUCN 2014).

The ever concentrated populations on some of these islands are now experiencing overexploitation of oceanic resources, which is discussed in the next section of this work.

Population growth and urbanization have been discussed as a possible source of resource exploitation in the Pacific Islands which in turn, creates food insecurity in the region and is urging islanders to come up with alternative sources of protein production (IUCN 2014). While at a *prima facie* level this sounds as though it makes sense, there have been other academic studies in the region which suggest a more nuanced reason for the overexploitation of coastal resources. This has to do with socio-economic conditions which vary among the Pacific Island demographics on all scales. What is revealed in these studies is that there are densely populated and “urbanized” areas on some of these islands yet no significant level of resource overexploitation, and there are other areas with lower population density levels and higher levels of resource overexploitation (Kronen, Vunisea et. al 2010). While some cases do correlate population with overexploitation, studies among 17 different Pacific Island Countries and Territories suggest that not only do population and fishing practices play a potential role in resource depletion, but the integration of Pacific islands into a Westernized cash-based economy, coupled with the *lack of alternatives for income* not based on commercialized fish also play a more significant role in the overexploitation of marine life in the Pacific Islands (Kronen, Vunisea et. al 2010).

This study suggests that the necessity for fishery management strategies which focus on a multitude of factors need to take place in order to ensure sustainable harvesting practices from ocean resources. Another study concluded that coastal fisheries will not be enough to ensure food security in these regions, but that in-land and

freshwater aquaculture is recommended in order to address the lack of productivity of coastal fisheries (HLPE 2014, Bell, Kronen et. al. 2008). In all cases of food insecurity in the PICTs region, aquaculture, the growing of fish, has been recommended as a vital factor in achieving food security. However, aquaculture comes with its own set of problems despite its importance and significant role in promoting food security for Pacific island fishing communities. This will now be discussed in the following section. Discussed in the next section? If so say this. Otherwise summarize the problems of aquaculture

Aquaculture for food security

Whether food insecurity comes as a result of climate change, imported food dependency, resource overexploitation, or the lack of viable economic alternatives on the national and local levels, aquaculture “the breeding of fish has been a significant component within the academic discourse (Adams and Labrosse 2001). It has been championed as a solution to the negative impacts that climate change can have on local fisheries, creating opportunities for economic development (Adams and Labrosse 2001), reducing dependency on imports, and as a necessary response of the overfishing of the oceans (Ibid.).

However, aquaculture in its most idealistic motives still fall short of meeting this paper’s working definition of food security in that it is not necessarily environmentally sustainable and that further environmental regulations are needed in order to ensure environmental protection from its potentially harmful attributes (NYTimes 2005). Aquaculture alone still has its own set of problems in that it can “severely degrade aquatic ecosystems, pose health risks to consumers, reduce incomes and employment in

the capture fisheries sector, and diminish food resources for poor populations” (Klinger and Naylor: 249, 2012). It can also deplete fish species in the wild (Lorica and Ahmed 2002), it can demand scientific/technical knowledge and high investments of capital, and lack a more agroecological approach to growing food (Wienberg 1996). Aquaculture also falls short in providing a diversified diet of plants and vegetables on a local scale which have been argued as a necessary component of food security (Carolan 2013). In brief, if aquaculture is to ensure food security for PICTs, it would need to promote the well-being of Pacific islanders socially, economically and environmentally. It is argued here that since aquaponics incorporates more agroecological principles than aquaculture alone can provide it therefore has the ability to provide a more holistic approach to food production which is vital to improving food security.

Specifically, aquaculture does not incorporate both animal and plant farming practices, produce on low energy inputs, be accessible by most if not all, incorporate resource conservation practices such as nutrient recycling and contribute to the local consumption of a healthy and diversified diet. This is something that aquaculture alone cannot do because aquaculture by definition is the production of fish and marine life exclusive of important agricultural crops such as vegetables. Further, much of the conversation within food security literature for PICTs discusses production for export and income and not enough is said about production for consumption. This is an important point to make because local production for local consumption is one of the main components in achieving food security today. It is here that I would like to introduce aquaponics as a viable alternative for food security in PICTs, in that it has the ability to provide the benefits of aquaculture (fish as subsistence and as a resource conservation

technique), contribute to a diversified diet needed for adequate nutrition and can also be done in a socially accessible, economically beneficial and environmentally sustainable manner.

Aquaponics

Aquaponics: Agroecology, Sustainable Agriculture, and Food Security

In response to the three eras of food security discourse and initiatives has come the discourse on environmentally sustainable forms of agriculture. The Industrial led agriculture had negative impacts on the environment and small-scale farmers around the world, including the loss of soil fertility, access to land, biodiversity, and ultimately food among local producers and those on the lowest socioeconomic levels (Altieri 1989). Sustainable agriculture seeks to respond (but is not limited) to these negative social, economic, and environmental impacts or “development oversaturation” by incorporating the principles of agroecology (Altieri 1989).

Agroecology can be defined as a “knowledge intensive” (as opposed to capital intensive system based on some of the fundamental principles (Altieri 2011): The application of ecology to the design and management of sustainable agroecosystems consists of “Linking ecology, culture, economics, and society to sustain agricultural production, healthy environments, and viable food and farming communities.” (Gliessman)

This definition can be explained as a system of agriculture that incorporates existing functions of a specific environment or natural processes (ecology) into the local production of food -based methods. These methods ensure the ecological continuity through practices that are “known” to be successful within the local community engaged in the agricultural practice. Within the field of agroecology there are numerous principles

and goals that are intended to ensure the health and sustainability of the environment and are necessary qualifiers of agroecology itself. While these goals are too expansive to discuss here, I will explain some of the core principles so as to show how aquaponics relates to the field of agroecology.

Some other core principles of agroecology consist of: the integration of livestock with crop production, diversification of plant species, enhancement of soil matter, *recycling of nutrients* and energy instead of the use of external inputs and water conservation. Also fundamental to agroecology is the management of any food system by indigenous or local people that incorporate traditional farming knowledge into its production (Altieri 2002, 2011). Inextricably linked to such principles are the concepts of natural resource conservation that not only protects soils and water quality but that such methods are aimed at reducing the costs of production (Altieri 2007). Agroecology has been argued by scholars as “perhaps one of the only viable options to meet present and future food needs” (Altieri 2011). Since I am arguing for aquaponics as a subset of agroecology, it can be inferred that aquaponics is or has the potential to be an environmentally sustainable food system that can contribute to food security.

What Is Aquaponics?

Aquaponics is a food producing system that has emerged as a popular form of sustainable agriculture over the course of the last few decades. Sustainable agriculture has been defined as an environmentally safe way of producing food which must contain three components: “plant and animal productivity, environmental quality and ecological soundness, and socioeconomic viability” (Neher :53-54 1992). It is a farming system that combines techniques and functions of both hydroponics and

aquaculture (Hillyer 2007, Rakocy 1992, Belsare et. al.). Hydroponics, an agricultural system which uses water instead of soil as its growing medium is combined with the ecosystem of a fish tank. Instead of earlier forms of aquaculture, “the growing of aquatic organisms for food” or “fish breeding as a branch or industry”(Goodman 2011:10) which typically released polluted water into the environment, aquaponics uses a technique of Recirculating Aquaculture System (RAS) which recycles water from a fish tank into a containment pool whereby crops are grown (hydroponics) instead of adding new clean water to the system (Silcox 2013). While just beginning to increase in popularity in modern times (Hillyer 2007), agricultural practices using the combination of fish and crops dates back to the times of the Aztecs where they created “Chinampas” or floating gardens which were fertilized with lake water (Mollison 1992, Goodman 2011).

Aquaponics, as such combination provides many benefits that each cannot provide independently of the other. These benefits range from positive effects on environment (Nichols 2012), provision of healthy and safe food, energy and resource conserving techniques and a low cost (Cufone Ted talk), low labor intensive way of producing food (Belsare, Singh et. al. 2007). The benefits of aquaponic production can play an important role in achieving food security, in that it attempts to respond to many forms of insecurity, including groundwater pollution, climate change, and overfishing of oceans, while providing diversified and healthy food (Bernstein 2011). Also, as a highly efficient source of localized production it is a direct response to the dependence upon imported food.

Benefits

Aquaponics contains all three elements of social, environmental and economic benefits, and therefore it fits into this studies working definition of food security when employed on a level for local production and consumption. I will now discuss how aquaponics provides benefits in all three components of sustainable agriculture.

Due to the fact that aquaponics is the combination of fish to plant life habitat, a living ecosystem is created whereby a symbiotic relationship becomes essential to the very functionality of the system (Weinberg 1996)). This means that the survival of the fish is dependent upon the healthy production of plant life and vice-versa. For example, the fish waste/effluent in the form of ammonia that is produced in the fish tanks is channeled into the plant beds which the plants take up as food after a natural process of fixed nitrification has taken place (Weinberg 1996, Rakocy 1992). At the same time, the plants take up the nitrate nutrients as a natural fertilizer which has been converted from ammonia; the water is then “cleaned” for the fish tank environment as the ammonia has now been removed from the system. Once the water is filtered through the plant beds it is then channeled back into the fish tank as healthy water for the fish to live in. This natural process is well documented within the scientific disciplines and is known as the “nitrogen cycle.” The clean water is then fed back into the tank providing a continued and healthy habitat for the fish and where the cycle can then be repeated (Belsare, Singh, et. Al. 2007) . This is known as a recirculating system because there is no waste at the end of this process and the cycle as in aquaculture (Weinberg 1996), which is repeated, and is done without any added inputs. This method must be organic in its very nature

because if any chemical inputs are added then the fish population would die off (Huffingtonpost 2011). If the fish die off then the plants begin to die as well (Martinez 2013, Igisiar Interview April, 2014). This is what is meant when aquaponic specialists call the system a symbiotic ecosystem or living system (Goodman 2011). Thus, aquaponics is environmentally sustainable in that it cannot use any chemical inputs nor does it release any waste into the outer environment; it uses an integration of plant and animal productivity and provides an ecologically sound mode of food production.

Aquaponics is able to provide a direct social benefit to the community by not only producing food but nutrient dense food that is healthy and safe to consume. Scientific studies done on the vitamin and mineral content in aquaponic food has shown that aquaponics in many instances can actually produce higher yields in nutrition than traditional agriculture (CTAHR, ATOLL courses, notes from Aquaponics in Hawaii conference held at Windward Community College on Oahu). The food is also safe because what threats to health that traditional agriculture can have, aquaponics can outright avoid. For example, many threats to consumption can come from soil borne diseases and even organic fertilizers that have not been composted long enough, such that non-beneficial bacteria is still present. As a type of soilless agriculture which uses fish effluent as its main source of fertilizer, aquaponics avoids these threats and becomes a safe and healthy way of producing and consuming food (Belsare 2007, Martinez 2013). Aquaponic food can also be grown in a highly efficient manner as it can produce food 2-3 times faster than traditional agriculture (AquaponicsParadise.com). Thus, aquaponics looks to provide a social benefit of healthy, fresh and safe food to those practicing this

method of agriculture, which is a previously mentioned criteria of sustainable agriculture, and contributes to overall food security.

Aquaponics is a model of energy and resource conserving agricultural practices which directly and indirectly contributes to its own economic viability. This is because of its ability to produce huge amounts of food on very little energy (Martinez 2013, Saipan Tribune 2013, Cufone,). While there are different ways of transferring water from the tank to the grow beds, such as water or air pumps, aquaponics also incorporates natural forces in its processes. Many systems use gravity during at least one stage in the movement of water, which does not take any energy at all (Hallam 2011). For the systems that do use water and air pumps to move water from tank to grow bed, the amount of energy pales in comparison to traditional forms of agriculture as will be further elaborated upon in the case study. There are even cases in Haiti where rural villages are recirculating water from fish tank to grow bed on hand pumps with no electrical use at all (Perry and Rittgers 2004). Low costs of energy save farmers money and provide economic benefits which make this system more viable as a form of sustainable agriculture (Altieri 2007).

Aquaponics is resource conserving in many ways. First, in a recirculating system, it recycles and reuses water on a continual basis. The only water that is lost comes from evaporation and plant absorption. The water that is not absorbed by the plants overflows the beds and again, is channeled back into the fish tanks. This means that aquaponics uses 80-90% less water than traditional agriculture. 80-90% water conservation is huge and the implications for this globally cannot be overstated (Martinez 2013, Huffingtonpost 2011). This means local food production can become possible in

areas which lack enough water for traditional agricultural methods. Second, it is a soilless type of agriculture which means in soil deficient areas, aquaponics can serve as a way of preserving overused lands and over time these lands can become more nutrient dense and even produce food once again. In this way it can conserve land, an essential resource for food production. Aquaponics contributes to land conservation in that systems can be built on concrete, “marginal and peri-urban lands” (Klinger and Naylor 254: 2007) such as deserts and winter climates, in small spaces, and even grown vertically (Cufone). Aquaponics conserves water, soil, land and energy, which contributes to the overall environmentally sustainable nature of the system.

Another social benefit of aquaponic production is a low-cost low-labor way of producing food, because aquaponic systems can be created with materials of varying sorts (Cufone). Systems can be made from recycled barrels or pvc materials. They can even be constructed by non-industrial methods (Internship at Olomana Gardens 2013). This makes aquaponics more attainable for those that may never be able to purchase tools and machinery such as tractors that are necessary for traditional agriculture. Aquaponics is a low-labor method of producing food in many ways. First, the time that it takes to manage a system is minimal compared to traditional agriculture. Monitoring an aquaponic system once established consists of checking water proper Ph, nitrite and nitrate, dissolved oxygen and ammonia levels, checking for clogs in filters and feeding fish (Internship at Olomana Gardens). While the fish food can vary, the fish food mostly consists of a protein fish meal and is an external input that will be discussed later in this work. This level of labor consists of dropping water into a testing kit and mixing it with the proper solutions. There is no weeding or bending over to remove your harvest.

Harvesting fish can be accomplished by using nets and the grow beds are often built waist high where harvesting can be done from a standing position (Internship at Olomana Gardens).

The ability to use recycled materials and farm with little effort makes aquaponics attractive for those who lack the means and physical ability to perform the duties of traditional agriculture (Cufone). These benefits reveal social, environmental and economic benefits to those incorporating aquaponic practices, which are necessary to fulfill modern definitions of sustainable agriculture and food security.

Limitations and Vulnerabilities

However, limitations do exist. These limitations consist of dependence on electricity for the movement of water, skepticism about commercial viability and issues concerning health and safety (Klinger and Naylor 2007). Any loss of electricity can result in total death of an aquaponic system (Martinez 2013). For this reason, anyone using an aquaponic system needs backup procedures to protect from potential death of all fish and plant life. Adaptations have been made in order to reduce the likelihood of catastrophic failure, including backup power sources such as batteries, generators (Martinez), and even hand pumps (as demonstrated in Haiti) to circulate water. These vulnerabilities have occurred in the case study described below and have been mostly resolved to date.

Concerns over safety consist of the potential of cross-contamination when growing plants next to animals and may result in diseases such as Salmonella and Escherichia coli. There are also consumer concerns about whether or not the produce is safe to eat that has been grown by fish feces (Klinger and Naylor 2007). That being said

when properly managed the food can actually be healthier than some traditional crops (CTAHR Aquaponics in Hawaii Conference 2013). This is revealed in some scientific studies which show increased levels of minerals and nutrients in vegetable crops when compared to contemporary methods of agriculture (Ibid.).

Aquaponics as Important to Food Security for PICTs

Aquaponics as a fish and vegetable producing system is relevant to the state of food insecurity for PICTs. While most of the literature is focused among the scientific studies (Goodman 2011) there is still much to be done when considering its contribution to enhancing food security and it is here that this thesis intends to contribute. First, it produces fish and vegetables in a context of depleted marine life and dependency on nutrient deficient and imported food in the Pacific region. This depletion is due to such factors as the warming of oceans, which affect migratory patterns of fish; overfishing, due to the commercialization of traditional fishing communities and loss of traditional fishing practices; and the lack of purchasing power for alternative diets. Second, by producing fish and vegetables on land, aquaponics provides a direct benefit to the Pacific communities by mitigating the negative impacts of overfishing and simultaneously reducing their dependence upon expensive and nutrient deficient imports. Third, aquaponics also contributes to the health of such communities by producing safe and nutritious food, something which current imports have been criticized for being unsatisfactory. Aquaponics has already sparked the interest of development agencies and governments within the PICTs on preliminary and experimental levels.

Finally, as a form of food production which incorporates agroecological principles through soil and water conservation, animal and crop integration and

localized/indigenous management practices, aquaponic production seeks to situate itself into the current concepts, definitions and context of food security for Pacific Island Countries and Territories. In sum, aquaponics can provide a social, economic and environmental benefit to PICTs in a way that is responsive to their current state of food insecurity.

Methodology

This thesis is the result of over a year and a half of research. To better understand how aquaponics on Rota is connected to progressive conceptions of food security, I spent two weeks on the island during the months of May and April 2014 conducting fieldwork. The results of this fieldwork appear in the 13 interviews I conducted during this time and provide insights into how aquaponics contributes to food security initiatives from multiple local perspectives. Interviewees consist of the Mayor of Rota, his campaign manager, advisor, treasurer of Rota, a committee member for the aquaponic grant project, 4 out of 5 aquaponic trainees known as the “Rota Team” a couple members of the community who were not originally affiliated with the project. This fieldwork was done in conjunction with over a year of reviewing literature on aquaponics and considering it within a food security context that is scarce within academic literature. This review encouraged me to better understand aquaponics from a participatory perspective, which I found in my internship on the island of Oahu. I spent 10 weeks working more than full-time and studying aquaponics on a functioning aquaponic farm. This contributes to part of this study since it helps in my understanding of the process that the Rota Team went through and the functions of aquaponic systems as well. It was there that I learned of the

“Rota team” and focused the rest of my interest in acquiring first-hand accounts of the Rota project.

Inception of Research Project and “Finding” Rota

The goals and interests of this project are both personal and professional but have been mostly guided by my passion to work with people around the world who are driven to improve not only their own lives but those of their community, and ultimately to contribute to the betterment of the planet, be it only on a micro level. My initial reading on aquaponics led me to Olomana Gardens, an aquaponic farm on the island of Oahu that teaches construction, implementation and maintenance of aquaponic systems. Here, in spring 2013, I spent over two months learning how to build and monitor functioning systems and eventually running the aquaponic farm by myself for three weeks. It was on Oahu where I first experienced the viability of aquaponic farming.

From 2013 to the winter of 2014, I spent my time reviewing more aquaponic literature, and I now realized that the literature was lacking on food security initiatives and that a case study to argue for the viability of such sustainable agricultural systems were imperative for international studies purposes. Going to Rota to document what they have done became imperative for my research questions. In March 2014 I first contacted Mr. Frank Atalig, the municipal treasurer and grant program manager of the Rota aquaponic project, who welcomed me to visit and learn from the local community that was and are still is growing food aquaponically.

Research Design

The research design consists of a literature review of food security definitions and concepts, an overview of relevant food security literature for Pacific Island Countries and

Territories, and a methodology of gathering data both qualitative and quantitative at the research site on the island of Rota using a post-structuralist theoretical framework of PRA/PAR coupled with a focus upon agroecological principles (Putnam et al. 2014). This is because it has been argued that the use of both qualitative and quantitative data is important and mutually reinforcing for any research within the social sciences (King et.al 1994) and a methodology of PAR coupled with agroecological principles is necessary for enhancing food security (Putnam et. al. 2014). The data received comes from a case study on Rota and demonstrates how the aquaponic project serves as a viable option for approaching food security within a Pacific Island Commonwealth and Territory (PICT) context.

Qualitative and Quantitative Methodology

For the quantitative aspect of this research, I worked with Frank Atalig in gathering the data documenting the costs of the aquaponic project through the entire process. This was possible not only due to the transparency of the project allowed by the local Mayor's office (transparency doc.), but because of the strict record keeping of Mr. Atalig. He provided me with hundreds of documents that revealed the costs of the project. Costs in the form of materials purchased, education and training receipts of aquaponic specialists, delays in material deliveries, and construction are all documented and have been incorporated into this study. This has been done in an effort to provide a real case cost-benefit scenario for any organization or community looking to implement aquaponics as a food security initiative.

The qualitative portion of this study was accomplished through interviews on Rota and my hands-on training in Oahu in an effort to learn what is needed in order to run

and maintain a successful aquaponic system. The lack understanding between application of social science theory and on the ground implementation is a real problem for researchers when constructing relevant interviews (Hollway and Jefferson 2000) and trying to understand motivations for certain system designs. In light of this, I tried to minimize the disconnect between application and theory by learning the construction and maintenance of any aquaponic system by first-hand experience. In fact, I went through the same internship and education process as the Rota Team themselves.

Interviews

The process of setting up interviews was relatively easy because I had the help of Mr. Atalig who provided invaluable insight into the process. We agreed that providing the study with multiple perspectives would contribute to raising varying concerns within the community and would allow me to generate new questions accordingly. After each interview, I would share with Mr. Atalig the findings and new questions raised, then say something like, “now I need to find out how a different perspective might challenge this approach and contribute to our understanding.” He would then make a call to a person which he determined to be able to contribute a relevant perspective and set up an interview in order to gather more data. In this way the interviewing process was very fluid, interacted, reiterative and participatory. That being said, it should be noted that this process is entirely dependent upon Frank Atalig’s determination of who I was put into contact with. In this way the limitation of the study is revealed and demonstrates a substantial bias in the methodology.

For the governmental perspective I met with the Rota mayor, Director of Department of Land and Natural Resources and employees, workers within the Mayor’s

office, and Mr. Atalig himself, as the grant manager of the project. The data collected on from the governmental perspective consists of the motivations of the project, the grant application process, implementation of the funds, obstacles and lessons learned and the goals of the actual project itself.

The second perspective that I was able to interact with was that of the aquaponic specialists themselves. This perspective is very important as it comes from those actually on the ground who are implementing the project with their own sweat and labor. This perspective is also important for communities and organizations wanting to engage in such a project, as it provides real insights that are not on any theoretical level.

The third perspective comes from only a couple community members interested or not in the aquaponic project itself. This too is important, as it reveals concern within the community about how food security is not only perceived but achieved. My aim in interviewing such individuals was to provide a local and cultural perspective that views aquaponics as not only adequate and appropriate but viable and desired from a “bottom-up” approach.

Theoretical and Practical Applications of Research Framework

In my research, I did not use surveys, questionnaires or any form of pre-written dialogue in an effort to understand the Rota food security project. I did however know that formal and semi-structured interviews would be necessary and in preparation for this I gained approval for a human subject IRB clearance. When preparing for the field work portion of this research I understood that any questions made and asked prior to the fieldwork would only impede the research data. I acknowledged that as an individual not from the island it would be difficult for me to gather research without working with a

local community member. Mr. Atalig took charge in contacting and setting up all of my introductions and interviews, and he helped me, through hours of discussion, to understand the Rota context of food insecurity and what is driving the local push to produce food alternatively in the form of aquaponics. This process of working with community members in the gathering and analysis of research is known as *Participatory Action Research* (PAR), and it is the main methodology employed in this work.

During this process we also sought out individuals with opposing perspectives so as to highlight challenging views within the community. These views are incorporated into the study and will reveal a concern for the overall viability of the project. We thought this would be important in that one of the purposes of this case study is to reveal obstacles and varied perspectives. It is hoped that this method will become more aware of some of the inevitable hindrances that will be experienced when any community engages in such an endeavor as this.

PAR is a post-structuralist method that seeks to equalize power relations between researcher and community members by treating all participants in the study as “competent agents” who contribute *multiple perspectives* to “examine a problematic situation and change it for the better” (Putnam et. al. 2014). Through a process of PAR, I am better able to identify the food security concerns of the community from varying perspectives as well as varying motivations for the aquaponic initiative (Putnam et. al. 2014).

I recognize that perspectives from one scale, such as government or “aquaponic specialist,” do not accurately speak or represent the whole community. In an effort to depict a broader image of food security concerns and motivations, Mr. Frank Atalig and I

were able to set up interviews that took a three-scaled approach to data collection. This entailed Mr. Atalig contacting and setting up my interviews and sit-down discussions with government workers, aquaponic specialists, and educators, as well as concerned community members. However, it should be noted that since Rota is a small island with a population of roughly 2,000 people, the government workers and aquaponic specialist are also considered community members. By “community members,” then, I mean locals who are not involved in the implementation of the aquaponic project in any way nor are they employed by the local government. All three scales of the research data collection all reinforce each other in not only providing varied perspectives, but in creating a more precise image of why Rota seeks to improve its own food security through aquaponic farming and how it is currently doing so.

Since I am researching the aquaponic project as a case study, I am not informing the people of Rota that aquaponics is or should be important to them as a viable option for attaining real or relative food security; rather I am asking this approach is being promoted as a viable option of food production and how they have come to actualize the program with varying degrees of insecurity. The aim is that their efforts can become popularized and serve as a model for others to follow or learn from when developing food security initiatives in the future.

Another important aspect of this work is that after its acceptance into the thesis records of the University of Oregon a copy of this thesis will be sent back to the field. The concept of repatriation is important for a variety of reasons. First it comes from a deep place of gratitude from me to those that gave me the time to be interviewed and to share their lives and local concerns with me, someone who they had just met. It is also

important for the community to know what has been written through this process and it has been argued and I agree, that those studied or communities from which research is gathered have the right if not more to access of to what has been written about their culture and livelihoods than those conducting research (Jaarsma). I also feel that it is important to repatriate the work in that it keeps researchers honest and more accountable to what they end up producing on a professional level. It has been discussed by scholars that the process of repatriation ends up providing continuity in the fields of the social sciences in that it contributes to the willingness of communities to accept future researchers into their communities (Jaarsma).

CHAPTER III

CASE STUDY OF THE ROTA AQUAPONIC PROJECT

Local Government Perspectives

This Section looks at the case study and is divided into three sections. The first comes from members of the local government and looks at the present state of food insecurity on the island and the motivations for the aquaponic project. It describes the construction of the project itself and how the evolution of its main goals came into being. I suggest that the multiple goals of the project are situated within a social, economic and environmental framework of promoting food security. The second section looks at the aquaponic project from the perspective of the aquaponic specialists themselves and reveals the motivations, goals, and implementation of all three phases of the aquaponic project. What is also revealed here is the “process” of the project concerning obstacles and negotiations thereof. This is used as an argument for the viability of the project itself coming from an on the ground perspective in order to provide valuable information of the aquaponic project as a case study. The third section discusses the concerns of food security from the perspective of a couple community members directly and not directly affiliated with the aquaponic project, which reveals a community desire for aquaponics and how it might be perceived in contributing to the overall food security of the island.

What this section shows is that the motivations and goals for the project are varied yet cohesive when looking at a wide range of perspectives. These perspectives reveal that a deep concern for food security exists on the island, as the project designers are

taking a comprehensive and educational approach that incorporates all those who are interested into the scope of the project.

In each section I seek to make two main arguments: First, that the viability of the aquaponic project is dependent upon a deep commitment to the well-being of the community and island as a whole. Second, that in order to achieve the hurdles of a successful operation, education that promotes agency/empowerment (the ability to make choices and engage in the practice of aquaponics) is the necessary component. The education that is provided on the island is intended to address a broad scope of food security and access. If the Rota community is to perpetuate the implementation of aquaponic systems both on a small and large scale, which are the overarching goals of the project, both points are necessary (commitment and education). I then conclude by incorporating current research giving an explanation of what I think the Rota initiative means to existing literature on food security in order to show how Rota advances the food security/aquaponic discourse among PICTs.

Government Motivations for the Project

The initial motivation for the aquaponic project was food security. The government found the territory to be in a “state of emergency” (Frank Atalig email to Assistant Secretary of the Department of the Interior Mr. Babauta) due to its geographical isolation and dependency upon food imports. Two main factors helped in the construction of the idea for aquaponics on Rota: Within the island there was and is a concern for health, food security or reducing deducing island dependence on imports, and for the reengagement of newer and younger farmers to enter into the farming sector. Exterior to the island was a proposal by the Department of the Interior inquiring about the

“needs of the community” on the island. This and past agricultural policies which were not successful all converged into the inception of the aquaponic project.

Internal Factors

Within the last few years agriculture has been a major concern for the local government of Rota. This entails improving the production of food locally in order to reduce dependence on agricultural imports. Imported foods have raised a variety of concerns on the island consisting of issues surrounding health, cost and access. To confront some of these issues the local government, under Mayor Melchor Mendiola, implemented a “dirt to backyard policy” that sought to increase the access to healthier and more affordable food on a household level by addressing the geographical locale of Rota’s villages and the distance of locals from nutrient rich soil that exists on the island (David Atalig Interview).

Because of the fact that many individuals cannot grow food in their backyards, the local government sought to assist in providing nutrient rich dirt to the backyards of community members (David Atalig). On Rota, food is not only expensive, but most people on the island are on food assistance and receiving food stamps as part of their monthly food budget. Due to the expense of food most purchase what they can, which naturally results in cheap food lacking nutrition. Dirt in the backyards is needed since most people that live in the villages (Sinapalo or Songsong) have a growing medium of limestone. Rota is an island made up mostly of coral, and therefore, farming becomes a major difficulty. The nutrient rich soil is not in the local village but up in the Sabana or higher altitude of their local mountain (David Atalig). Since most cannot afford the daily drive to monitor and maintain a farming livelihood away from their homes (let alone the

cost of inputs needed for sustainable production) many cannot or just do not farm. Mr. Frank Atalig called this the “Rota Dilemma”, meaning the island has abundance but lacks the ability needed to harness such resources in order to benefit the local community. This dilemma has been a motivating factor for leaders in the community to find alternatives that not only meet the needs of the community but are viable within this geographical and cultural context. Access, that is, is a food security issue on Rota, both access to healthy food and access to methods of agricultural production.

In response to this geographical hindrance one will see many people growing or trying to grow food in plastic buckets in which they have transplanted soil. This practice has been viewed as unsustainable in that it calls for plastic containers on a large scale to be acquired for the limited production of food. Within this context the municipal government under Mayor Mendiola decided to try the “dirt to backyard policy” (David Atalig Interview). However, this proved to not only be difficult but inadequate due to “costs and environmental laws”. The costs of transporting large portions of dirt to everyone’s backyard demands tools like tractors and manpower, all of which demand money. The local government, which is already in debt on many levels, could not actually bring dirt to everyone (Tenorio 2006). On top of this are environmental restrictions that do not allow for people to just dig up soil and move it from one spot to another. Because of federal laws, Rota could not follow through with its dirt to backyard policy, and as a result it needed another solution to the food security issue (David Atalig).

This prompted Mayor Mendiola to discuss with Frank Atalig what other alternatives or resources might exist to address the agricultural dilemma on Rota, and here aquaponics becomes very attractive. Mr. Frank Atalig, a farmer found that through

small-scale aquaponic production, the people of Rota would be able to produce environmentally sustainable food in their own backyard despite the lack of nutrient rich soil. Since aquaponics has the ability to produce food on a small scale and without the need of nutrient rich soil, the aquaponic project seemed to address the two main issues of local production without nutrient rich soil. What is revealed here is that issues of access and environmental sustainability provide the context within which Mr. Atalig was personally encouraged to address the concern of food insecurity.

External Factors

Events that helped engender the aquaponic project exterior to the island have to do with the unique relationship between the U.S and its territory of Rota. Since Rota's admittance to the U.S. in 1978, the U.S. has been charged with the responsibility to encourage and assist in the development in Rotan self-sufficiency (Congressional testimony of Pedro Tenorio 2006). There have been many visits to the island by the Department of the Interior that evaluate needs of the community. On one such visit, the Assistant Secretary to the Department, Mr. Babauta, was discussing the most prescient needs of the Rota community with Mr. Atalig. It became evident that Rota is in a "state of emergency": a pattern of needs emerged that all centered around agriculture.

Mr. Atalig met with a range of local people and institutions, including members of the Department of Land and Natural Resources (DLNR), Department of Commerce, Northern Mariana College Cooperative Research, Extension and Education Service (NMC- CREES), and Mayor Mendiola. He uncovered issues of food security consisting of the lack of any farmers among the next generation, concerns within the community of increased cancer rates and diabetes, the fear that this was connected with imported foods,

and the fact that Rota is in dire need of a commodity export industry if it is to become a self-sustaining island. These concerns, coupled with the fact that the NMC-CREES and the Department of Commerce were working on an experimental aquaponic project, all helped in the motivation to address food security and as Mr. Atalig says, “to do something about it.” The research here suggests that motivations for the aquaponic project began at the “top” (governmental/institutional level) but initial assessment of concerns within the community based on “need” for self-sufficiency, revealed an issue of food security that must be addressed. This also reveals the beginnings of a top-down/bottom-up process that has continued to evolve over time and into the present context for the project.

Governmental Goals for the Project

There are numerous goals that the aquaponic project seeks to address. Its main goals from the government’s perspective are “to encourage our younger generation to take on farming for food through aquaponic systems that lessens intensive labor, increases crop yield, steer away from conventional methods and introduces organic farming,” according to Mayor Mendiola (Interview with the Mayor April 2014). Additionally, as Mr. Atalig adds, this project aims to “curtail our island from total dependence on food imports and alleviate a growing shortage of food.” (Frank Atalig Interview April 2014).

These statements demonstrate the intentions that Rota has for aquaponic production. Reducing labor intensive forms of agriculture and increasing crop yields are goals that seek to attract locals, on the individual and/or household level, towards farming

as a viable form of employment *and* subsistence. To steer away from conventional methods of farming (chemical agriculture) shows that the concern for health and environmental sustainability is an important factor in achieving food security on the island. The aquaponic project also hopes to promote self-sufficiency on the community level by eventually creating a domestic market that reduces the need for imported foods. Research also shows that Rota intends to produce food on the commercial level where it can become an exporter of organic foods to neighboring islands. In this way Rota hopes to become a model for food security initiatives to other islands in the CNMI through aquaponic production. Research also indicates that the success of these goals is dependent upon the community accepting this initiative. Without the community embracing this alternative form of agriculture the project will not succeed. To ensure the continuity of the project, designers have made education the main method for achieving this goal.

Providing an alternative to traditional forms of agriculture is an important concern for the members of the government. This is because traditional agriculture is so labor intensive that many people on the island would rather opt-out than work all day in the blistering heat of the island (Mayor Mendiola April 2014). Because of this, Rota has experienced a dramatic decrease of newer and younger farmers on the island and a stable presence of immigrant workers mostly consisting of Bangladeshi origin in the fields (Fieldwork). While immigrant labor is not bad in and of itself, the point is to demonstrate that a lack of non-immigrant farmers is a source of concern to the municipal government. Aquaponics on Rota seeks to provide an alternative that does not necessitate the high amount of labor that traditional forms of agriculture demand. First, aquaponic production

can be constructed in ways that do not demand the farmer to bend over by building systems that are waist high. Aquaponic maintenance, once constructed, can be done in minutes and demands very little labor at all. Aquaponic production also removes the need for weeding in the traditional sense, in that only the crops that are desired are grown in the medium. It is the hope of the government that aquaponics attracts newer farmers as it seeks to address the issue of labor intensive agriculture on the island. By increasing the number of farmers on the island, it is hoped to then increase self-sufficiency and reduce dependence on government subsidies, which is another concern for the people of Rota.

The people of Rota are dependent on their local and federal government for acquiring and purchasing food. This is because more than 80% of the community is dependent on food stamps and more than 50% lives below the poverty line, according to U.S. mainland standards (Mayor Mendiola; Frank Atalig). Without this assistance the islanders would not be able to purchase the food that is imported to the island.

Aquaponic production seeks to promote self-sufficiency on the individual level by allowing them to produce their own food, thereby taking away the need to purchase food with food stamps or at the very least reduce their spending. This research shows that aquaponic production is seeking to empower members of the Rota community in a way that pulls them away from government subsidies upon which they are dependent.

Aquaponic systems can achieve this goal due to the fact that the systems are small and take up very little space and can produce a significant amount of food.

There is also a concern on the island that diabetes and cancer rates are directly associated with the imported diet that the majority of the population eat (Fermin Atalig;

Tanya King Interviews April 2014). Because aquaponics is an organic form of agriculture by its very nature it can directly contribute to the goals of the Rota government by providing food that has not been produced by petrochemicals in the form of pesticides, herbicides or fertilizers (Fermin Atalig Interview April 2014). “For me, one person not getting cancer from the growing of food and the use of chemicals is a success as a process of the aquaponic system.” (Fermin Atalig Interview April 2014). This concern to move away from chemical agriculture is important for the safety of the entire community because “farming in the Sabana may hurt the water table because of chemical agriculture” (Greg Hocug Interview April 2014). The water table is directly under the higher grounds of the Sabana or main farm land of the island. The concern that chemicals are affecting the islands fresh water supply carries a huge level of significance when considering Rota’s food security. Not only does aquaponic production provide organically grown food, but because of the relationship of plants to fish, the food provides unique health benefits in the form of nutrients that many places lack due to soil deficient grounds (CTAHR Aquaponics on Hawaii Conference 2013).

Once the project has promoted self-sufficiency and members within the community are growing food in their own backyards there then come opportunities for economic development. The main goal of reducing Rota’s from dependency on imports is not only addressed on the subsistence level, Rota hopes to take aquaponic production to the commercial level as well and export food to neighboring islands within the CNMI. In doing so, it will be able to sell and trade, which will then promote the domestic economy. Rota’s government officials hope that it can thus become a model to other

islands in the region in achieving food security and independence from expensive imports from the mainland U.S. (Mayor Mendiola Interview April 2014).

Addressing the motives behind the commercial goals of the project should be addressed before moving forward with the case study. It should be noted that in addition to there being an economic and commercial component to the project there are also those that stand to benefit and those who will inevitably not be able to benefit. Since commercial production will require huge amounts of access to capital, then it makes sense that in a community where over half of the population is living below the poverty line, that only few members will be able to acquire this goal. While it makes sense to assume that those designing the project stand to benefit most from this project this is simply conjecture and in no way invalidates the data gathered during the course of the fieldwork employed. However, it should be noted that asking questions like “who stands to benefit?” and “how those will benefit?” are important questions to ask. This issue is further elaborated upon in the recommendation section of the thesis.

The success of the aquaponic project is dependent on the acceptance and willingness to support aquaponic production on the community level (Greg Hocug elected official to the Rota municipal government Interview, April 2014). The project is not sustainable on the governmental level alone. Acceptance within the community has been addressed as the number one factor in achieving success of the goals mentioned above. Without the community buying into the aquaponic project then this initiative will fall to the wayside. This concern has been addressed by the project implementers through education. By educating the community on the benefits of aquaponic production, the government and the aquaponic specialists (The Rota Team) hope to see the

community embrace this form of agriculture. The focus on educating the community is considered to be the main factor of success for this project (Frank Atalig 2014). Not until the community has taken up the idea on their own and is “producing food within their backyard will this project be considered a success” (Frank Atalig 2014). The research shows that the success of this agricultural development is dependent on a government to community relationship that is based on education of newer forms of agriculture. What is revealed is that the sustainability of this project is dependent on the community and not the initial promoters of the project. I will try to demonstrate some concerns of a couple members within the community in an effort to demonstrate opposing and supportive views of the project.

The goals of the project, from the perspective of the local government, show that they hope that aquaponics will address food insecurity in a number of ways. By reducing dependency on government subsidies and imports, aquaponics looks to promote self-sufficiency and thereby contribute to improving access to food that would otherwise be unattainable. The project also seeks to promote consumption of healthier foods and thereby directly benefit the health of the community and the environment. The project designers not only seek to contribute to the physical well-being of its people, but also hopes to promote a domestic market which has the potential for export. As a more viable form of food production than traditional agriculture, the aquaponic project also seeks to incentivize newer and younger farmers within the island by educating them on the benefits of aquaponics.

This goal of economic development through aquaponics is dependent on the community embracing new forms of agriculture not previously known to the island. To

address this concern the government and project designers have specifically created an education component to the project, and they reveal that that education is the most crucial component to not only community acceptance, but to the overall sustainability of the food security project itself and its multifaceted goals. This implementation of this education component is addressed in the following section and my research reveals it as the most important factor contributing to the continuity of the project.

Grant Process

On September 24, 2012, Rota was awarded \$269,330.00 from the Department of the Interior for grant number D12AP00330. The start date of the project was January 15, 2013. The anticipated end date was projected to October 1, 2014 (Documents retrieved from Grant Manager).

Design and Implementation of Project Phases

The project has been designed into three different phases that are monitored by the program manager until the end date of the grant period. Once the grant portion of the project is completed it is planned that Rota's Department of Land and Natural resources will take over the project after September 30th and continue assisting members of the community in the construction and maintenance of aquaponic systems until the intended goal of self-sufficiency is achieved (*Nicolas Songsong, Resident Director of the Department of Land and Natural Resources, Interview April 2014*). Phase I consists of education and training of the Rota Team, phase II is the construction of the education facility, and phase III, the final phase, is the community outreach portion, where community members construct their own aquaponic systems with the options of growing food for subsistence or for limited commercial production.

Phase I: Education and Training

Phase I began on January 15, 2013, when five applicants from the island were chosen to travel to Olomana Gardens on Oahu to learn how to construct aquaponic systems and educate others to do the same. Here, the applicants would become specialists by passing a series of tests that have been developed within the University of Hawaii's Aquaponic Teaching and Online Learning program (ATOLL), as well as learning how to negotiate the obstacles that come with any aquaponic system (Jimmy Apatang, Jack Igisiar, Harry Mendiola, David Calvo Interviews April 2014) . Another aspect of the training was learning the actual construction of the systems themselves. From this phase of the project, the five individuals were to then take their knowledge back to Rota and teach aquaponic management/production to the rest of the community (Jack Igisiar, Harry Mendiola Interviews April 2014).

Phase II: Demonstration Facility

This second phase consists of the construction of an aquaponic system known as the "demonstration facility," that is used for the education and hands-on application of aquaponic farming. The aquaponic education and training center is intended to create a space and opportunity for the public to learn about the technology of aquaponics. It is also intended to inspire the community to apply for and eventually monitor their own systems, which will contribute to the overall mission of self-sufficiency and food security on the island (Frank Atalig Interview April 2014). If desired, the community can come and learn about the facility from at least two of the original five (Jack Igisiar and Harry Mendiola) individuals who are now the island's main educators and trainers of the project. The demonstration facility was strategically placed, according to Mr. Atalig, in

between the two villages of Sinapalo and Song-Song in order to provide a highly visible and “easily accessible” aquaponic unit. The demonstration facility is easily accessible in that it has no barriers of entrance, for example a fence, in order to invite the community to “come and learn” (Atalig 2014). With the construction of the demonstration facility in plain view, the community now sees the aquaponic units as a permanent fixture of the island right in the heart of the villages.

Phase III: Community Outreach

Phase III is made up of two major components which seek to work towards the food security on the island of Rota. First is the outreach to the younger generation on the island. This is an educational component that seeks to inform the local schools at all grade levels about the benefits and processes of aquaponic food production. In addition to having the demonstration facility for members of the community to view, the aquaponic educators also bring demonstrations to the public. (Igisiar; H. Mendiola Interviews 2014). Second is the direct training by the Department of Land and Natural Resources (DLNR) of local individuals and households in aquaponics. This will be accomplished by a process of using pre-constructed systems for a set time period in order to give the community a “hands on” understanding of these systems (H. Mendiola Interview 2014). The community outreach phase is intended to educate the community for the dual purpose of providing households with the ability to produce and consume their own food and as a motivation for able members of the community to invest in commercial-scale aquaponic systems (H. Mendiola Interview 2014).

As mentioned earlier, there is a deep concern that the younger generation is not interested in the laborious and traditional methods of farming (Mayor Mendiola

Interview April 2014). Since food security depends upon the local production of agriculture, it becomes critical that Rota produces its own farmers. In order to motivate and create an interest among the younger generation, the Rota team has and will continue to give public demonstrations at every school on the island, whether it be public, private, or the local college. By directly interacting with the children of all ages, “from first grade to high school” (Frank Atalig Interview #16) and even the local aging center, this portion of the project seeks to inspire the children to enter the local agricultural sector. This is a very bold and significant point for the argument laid out in this work, in that Rota, an island in the Pacific that is dependent upon external food imports, lacking in local farmers among the younger generation, is hoping to inspire its next generation to become farmers in aquaponic agriculture. This speaks volumes for the importance and significance of the case study presented here.

After the grant deadline on Oct. 15, 2014, the operation will be monitored by Rota’s DLNR. This process is intended to provide continuity to the projects, which eventually contributes to the overall expansion of access to aquaponic food production on the island. This is accomplished through an application process that allows those that have become interested in aquaponics to receive a system that has been built by the aquaponic specialists themselves. The main goals of phase III are to bring aquaponics to the backyards of its residents and to aid in the development of commercial exports (Songsong Interview 2014). In this way, phase III addresses food security in multiple ways as it also intended to reduce Rota’s dependency on expensive and intermittent imports.

The DLNR has designed a simple application where an interested individual or household applies for the delivery of an already constructed system. At the time of this writing there were 3 applications submitted with more expected to arrive. When approved, the DLNR delivers the system and the household/individual monitors and maintains it for six months while the DLNR visits and aids each household in maintaining the successful production of each system (H. Mendiola Interview April 2014). The crops and fish will be introduced into these small-scale systems so that, during the six month period, the system will produce two or three rounds of harvest without any added purchase. The only costs during this time will be electricity and fish feed (a legitimate obstacle to be discussed later). After this trial period it is hoped that the households purchase or learn how to construct their own system. If the system is purchased at a cost of \$1,5000- \$2,000 then the money will be used by the DLNR to construct another facility to then be distributed to another applicant. If the system is not purchased, then the DLNR will simply bring the system to another household which has applied, and in this way the project will continue to *educate the community* on aquaponics and hopefully encourage others to embrace the initiative.

Phase III is the final phase of the project and has just begun in its implementation (as of April 2014). At the time of writing, only 10% of this phase had been applied and much still needs to be done to see how the success of this portion of the project will turn out. What is revealed through this research is that phase III is mostly centered on the ideals of education and individual household empowerment with the hopes that some of the individuals who invest in the systems will be able to produce commercially as a

viable option for export. Limitations exist concerning the purchase of these systems, but if attained the benefits are residual with minimal costs.

Education in aquaponic production is the main aspect of this phase, and research reveals that it is the most important factor that is needed in the continuity of the project itself. Research also shows that the managers of this project understand this and have taken steps in making sure that the people who desire such systems will become specialists themselves. This final phase works to reduce dependence on government subsidies which are used on imported foods. It also hopes to build a market of commercial export which will not only benefit municipal government but the whole community of Rota.

Obstacles Encountered and Negotiated

Obstacles to the project consist of off island materials needed for construction, unforeseen changes during the implementation of each phase and allocation of funds dependent upon criteria of the federal grant, continued maintenance of the systems, food safety concerns, and the cost to the community that it takes for these systems to be constructed and maintained.. Since this is the first project of its kind, the project has had to address each obstacle without any prior experience on how to negotiate such issues. This however, is understood and has been accepted by the implementers of the project and they hope that the course they have taken to answer some of the inevitable obstacles can be looked at by other projects as a model of what to expect and how to overcome such issues described below.

Not all of the materials for the aquaponic system are found locally. In fact, much of the material—such as wood for the construction of the individual systems, pvc piping

needed for water and air movement, and the medium used for the bio-filter—has been imported. While the cost of these materials is covered under the grant, the hindrance comes from the fact that they need to be delivered to the island itself and maintained daily. This has been acknowledged as a legitimate weakness in the project, but in the words of Mayor Mendiola, “the benefits outweigh the costs,” meaning that even though these products must be imported, the situation is no different from what already exists on the island. However, the difference comes from the eventual benefits that will be acquired from on-island food production. Once the systems are constructed and producing food then the costs will dramatically be reduced.

Delivery of the materials has highlighted the dependence of the island on imports. During the course of the project, Rota has had to wait many months simply for the delivery of construction materials. The harsh weather that frequents the island at times prevents boats from entering the harbor, meaning that nothing comes to the island for months at a time. This not only stalls the project but delays progress and reveals the high level of commitment that is needed for the success of any project of this nature. When the harbor cannot be reached then sometimes goods are flown into the island, which increase prices two to three times (Igisaiar; H. Mendiola Interviews April 2014). Unfortunately, overcoming these obstacles simply means waiting. This point is important in revealing that the fact that the project is not able to fully reduce its dependency on imports argues against the sustainable components necessary for food security. The need for pvc, certain types of lumber and electrical equipment means this external dependency may always exist when discussing aquaponic food systems.

Other obstacles during the project entail unforeseen changes in how the grant money is to be spent. For example, within the framework of the grant, the manager did not take into account that there would be costs of travel and delivery of materials to the construction site. The cost of gas for the specialists to the work site and for delivery of materials from port to demonstration facility were not foreseen and therefore grant monies could not be used for such purposes. In addition, there were many tools needed for construction also not put into the framework of the grant, which meant that the money could not be allocated for such things. This also stalled the project (Frank Atalig Interview April 2014).

Negotiations of these obstacles come from a deep commitment to the project by the community members involved and the reframing of the wording within the grant. In response to the lack of tools and gas, for instance, the Rota team at times has used their own funds to make it work. They have been loaned or loaned out their own tools in order to continue with the work. They have spent their own money on gas as well (Igisiar, H. Mendiola, F. Atalig April 2014). Documents retrieved from the Rota treasurer show that some \$5,985.00 has been spent on the project as part of “community support.” This reveals that not only is a deep commitment needed by members of the community, but that it exists in the Rota food security initiative and has been necessary in order to get the project to its present state. . This demonstrated commitment is necessary for a project of this nature to exist and serves as a model for other communities in similar situations as Rota.

On a more critical note what this also means is that in an effort to sustain project of this nature any community might need access to private funds and preexisting access

to financial resources. I recognize here that this is a potential hindrance to the success of a project of this nature and it should be noted that access to financial resources is necessary for its continuity. This also reveals that those that are invested into the success of the project have the financial capital necessary to overcome these hurdles of lack of access. The point here is not everyone who is experiencing food security will not be able to acquire all of the materials necessary for a successful aquaponic system to be constructed. This can then be inferred that the success of this operation is dependent upon capital and people who already have the access to such capital. Since not everyone has this access, if the project is to be successful within this context then the community will need to interact with such institutions of power (the government) in order to benefit from the potential gains of aquaponic food production.

Additional costs exist even after the materials are acquired and construction is achieved. Fish food and the cost of construction has been recognized as a significant barrier for most people on the island. The purchase of fish food and materials is something that threatens the success of the project on a community wide level. In one interview, I was told, “not everyone will be able to buy the fish food” (Apatang Interview 2014) that is needed on a daily basis in order to keep the fish alive. This is especially true if systems within the community are not incorporating a duckweed or some other form of plant nutrient which the fish can eat. This cost of fish food may prove to be a significant barrier to the success of the project for those that are on the bottom of income bracket (Apatang Interview 2014).

Obstacles with regard to funds not allowed for allocation due to unforeseen changes in the project exist as well. For example, one of the original plans of the project

was to run the entire system on solar power, have the demonstration facility gated, and have the household systems purchased *and* constructed beginning with the application process. The solar panel portion was abandoned because the island's power company, the CUC, put a moratorium on solar panels (*Government Document*; Thomas Mendiola Interview April 2014). This meant that people on the island either had to go completely off the grid or have no solar option at all. The CUC says this is because of the "large backlog of applicants" (CUC document): they cannot support so many people partially feeding into the system where they would have to pay those feeding into the grid. While this makes sense from an economic perspective there are sentiments on the island that feel as though the CUC "should be very supportive of the people's need and be more productive in assisting the people in what the people need" (Greg Hocug Interview 2014).

Mr. Atalig did not like the idea of a gated demonstration facility as it "sent the wrong message to the community about the nature of the project." He wanted the community to feel encouraged to visit and learn about aquaponics, not to feel as though they could not be trusted or that the project was somehow "exclusionary." Problems also arose when considering that originally, the aquaponic systems would have to be purchased before construction. This meant that those in the community who were most vulnerable to adequate food and dependent upon financial assistance would have to come up with sufficient funds and resources before ever acquiring a system. This prerequisite threatened the very nature of the project designer's intended goals.

Negotiations to these obstacles came in the form of reframing the wording within the grant. Because of the moratorium, the purchases of solar panels were no longer an

option. The gate to the demonstration facility was abandoned as well. Meanwhile, the problem of households purchasing and constructing the aquaponic systems threatened the very success and continuity of the project, so in response, Mr. Atalig changed the design of the project and reworked the intended use of the funds. As a result, the money that would be saved from solar panel purchases and the construction of the gate would now be spent on building and delivering the household systems to the residents who applied. Now the households could acquire a system for a limited time and were provided the option of future purchases (Frank Atalig Interview April 2014). This reframing not only solved the problems of not being allowed to spend certain funds previously allocated, but also addressed the financial restraints that exist within the community considering the purchasing and construction of the aquaponic systems. This readjustment in the plan shows that those who are in charge of the project have made certain concessions in order to more directly benefit the community.

The need to readjust the construction of the demonstration facility also reveals another obstacle in the success of the project. The fact that members of the community will not be able to outright purchase these systems firsthand suggests that the lack of funds will and has posed a problem to many members on the island. The need for funds highlights the fact that capital is needed if a project of this nature is to be successful. While this may go without saying, it can be noted that this study shows that the federal grant is being spent with a particular focus of providing access to such acquired resources to the community in an effort to address this vulnerability.

The fact that solar power is not currently the main mode of power for these aquaponic systems highlights another vulnerability to the success of the project. Power is

incredibly expensive on the island and if free energy cannot be used to power these systems, then it only exacerbates and contributes to a preexisting financial burden that the community experiences every day. Power on the island runs 6-8 times the cost of average power costs on the mainland United States and this presents the members of the community on Rota with a unique position of inability to access the very source that is needed in order to maintain these systems. This idea will be elaborated upon later in the work when discussing how the construction and design of the aquaponic systems on Rota seeks to respond to these vulnerabilities, but it is worth noting here when on the topic of viable obstacles to the success of this project on a community level.

The research here suggests that not only are obstacles inevitable but that those who are involved in such a project need to be flexible and resourceful. Those involved in the project need to be able to adapt to obstacles and know how to negotiate through reframing issues if the use of grant funds exists. This section reveals that the need for funds exist and are necessary if a project of this nature is to even begin. This in and of itself can be very problematic when considering that those who are not able to purchase these systems are the ones in which it has been said the project is trying to benefit. The obstacle of access to a continuous supply of power and the purchase of such power highlights once again the issue of access and lack thereof. If power is not to be free in the form of solar then it seems that the cost of running such systems may only be able to be maintained by those who already have the necessary capital and definitely not by those who are living below the poverty line and are currently purchasing food from the government's nutrition assistance program.

Education and Community Development

This section of the thesis has shown the concerns of Rota's municipal government and project manager when considering food security and their motivations for embarking on the aquaponic food security initiative. I have attempted to describe and answer the "why is Rota interested in increasing food security through aquaponics question," from the perspective of government and project designers. I have done this by discussing the motivations and goals that have been outlined in the project manager's statements and members within the government responses as well. The motivations and goals of the aquaponic project show that the main goals of the project are related to reducing dependency on imported food, introducing a more environmentally sustainable type of agriculture to the island, increasing the island's access and variety to healthier and locally produced foods, promote a domestic market that reduces the people's dependency on government subsidies for food and also achieving a level of production that enables Rota to export cash crops to neighboring islands. In providing an answer to "how does aquaponics seek to enhance food security for Rota," I have outlined the initial project design and how it was intended in theory. Achieving these goals is dependent upon a commitment to the project by not only the government but, more importantly, by the community of Rota. More specifically, it is the younger generation that the project designers have targeted in efforts to revitalize the local agricultural sector on the island through aquaponics.

My research has shown that in order to achieve success for food security, education is an important factor for the continuity of the project. This is evident not only from the responses that I gathered or the focus on education that is represented in the

“education and demonstration facility”, but also in the fact that the project has spent almost half of its \$269,000 on education alone (Document Retrieved from the Rota treasurer April 2014). This financial commitment to education shows that the designers of the project realize that if a food security project of this nature is to be successful then an educated and informed community on aquaponic food production is necessary.

Education and community development is a common relationship that has been addressed in much academic literature. The research here shows that the Rota project is addressing food security in a variety of ways that reveal the progressive and empowering nature to this project. It is from this approach that Rota not only hopes to achieve its immediate goals of improve food security but also to educate other islands within the CNMI and even many other communities around the world of how a small and import dependent island might attempt to improve its own food security. What is important to mention here about the educational component to this project is that phase III has yet to be fully implemented in the community. This means that little has been done considering education, but the design of the project highlights the significance of sharing knowledge among community members as vital to the success of the project.

Aquaponic Specialists’ and the Community’s Perspectives

On the Ground Perspectives and the Aquaponic Educators

This chapter introduces the motivations and goals of the aquaponic project from the perspectives of the aquaponic specialists themselves. This contributes to the “why” question from a different perspective that guides this research as well as introduces the “how” portion of this work. In answering the question of how Rota has implemented the

project design mentioned above, I hope to bring in the voices of those actually on the ground. The educators or aquaponic specialists represent a variety of necessary attributes if any project of this nature are to be successful. As in the previous chapter, these factors include but are not limited to a deep commitment to the project by local Rotans, the importance of education to the purposes of the project and to the flexibility and resourcefulness that is needed in an environment that lacks certain manufactured products and is also dependent on imported goods. The purpose of this section is to provide a different perspective to the work from those that have actually brought the initiative from theory to practice.

Motivations for Project Educators

This section is important for anyone willing to understand the hurdles and solutions that have made this project successful to date and learn, as Mr. Atalig has said, “from the guys who have made this actually happen.” While these men are currently employed by the CNMI government, they represent a different perspective as they were not part of the grant receiving portion of the project nor did they participate in the overall goals of design of the project phases. Rather, it is their job to execute the phases and in effect actualize the plans laid out in the grant itself. Some of their motivations and goals for the project are to reduce the cost of food on the island, to provide a supplement to the monthly budget of food for those at the bottom of the income bracket thus improving health on the island, to provide a model of agro-tourism to visitors to the island, and to promote and popularize the overall methods of aquaponic farming as viable for agriculture in achieving food security. These responses come from the four of the five original members of the “Rota Team” that went to Oahu and were trained in aquaponic

and permacultural farming methods. Their responses demonstrate a desire to reduce dependency on imports, to promote self-sufficiency, and to encourage the next generation of farmers on the island to take up sustainable farming practices that improve the health of the Rota people and their island as well as provide a viable option of economic opportunities to those who are able to advance aquaponics on a domestic and commercial level.

The cost of food that is imported to Rota is highly dependent upon weather and other forces not expounded upon in this study, such as the international prices of crude oil. Rota has two ports, one that is functioning and another that is hopefully in the process of being opened up. The one port that is in use is very shallow when considering the type of freight and size of boats that need to enter the island. This makes it very hard for certain boats to enter the port as well as making the port itself susceptible to very choppy waters in the case of extreme wind and weather (Atalig Interview April 2014). Living with this inclement weather is part of the culture and life on the island due to the fact that Rota is situated in what is known as “typhoon alley.” In the case of extreme weather there are two options: one, that there will be no food delivered to the island, or two, that the imports can be flown in but at double or even triple the food price (F. Atalig; H. Mendiola 2014; Tenorio 2006). This demonstrates not only that food insecurity is affected by weather, but also that Rota depends on importation, which is a source of frustration on the island. It makes sense that aquaponics then, by producing food can aid in localized production whereby the island may alleviate some of the pressure that comes from this external dependency. However, it should be noted that the entire aquaponic system is dependent upon electricity and daily functionality. This means that in the case

of a typhoon or extreme weather the whole system could experience irreparable damage and thus undermine the goals of the project. This shows a high level of vulnerability exists within this project and it should be acknowledged by anyone who looks to support such a project.

Second, there are motivations within the Rota group to aid in the day to day production of food in an effort to provide food for those who lack the income to make monthly ends meet. The food subsidies received are not always adequate to make it through the month and in some cases people do not have enough food (Igisiair Interview April 2014). In this situation there is a strong support system within the community that shares with those that do not have enough. Supplementation of food purchases come from two sources, the jungle and the ocean, which, while they are not lacking in their production, are decreasing (Advisor to the Mayor Thomas Mendiola Interview April 2014). It has been noticed among the locals that the fisherman have to venture further away from the shore than in days past. Responses concerning this issue suggest that the overharvesting of the ocean and jungle are the preferred method of subsistence but the preservation of such practices are of major importance to the community and therefore the advocacy of aquaponics enters the discussion. Two examples such as the Fruit Bat and the Coconut Crab demonstrate concerns such concerns as these are endangered and members of the community hope to ensure their preservation. One of the goals of the aquaponic project is to reduce the need to enter the jungle for subsistence and, to allow for locals to produce food right in their backyards. This has the double effect of providing a supplement to the monthly food budget while simultaneously contributing to

the preservation of local resources which is important to members within the community of Rota (Igisaiar Interview 2014).

Another motivation for the educators to engage in the aquaponic project is to provide a model of agro-tourism to the island (Igisaiar Interview). Rota is well known for its tourism and this has always been a source of revenue for the locals since it became a territory of the United States in 1978. It is a desire within the Rota team to have tourists visit and see what has been done on the island in order to achieve two goals. First, it is hoped that when people come see the aquaponic facility they will not only learn about aquaponics but that “they will spend money while on the island.” Second is the hope that aquaponics itself will become more popularized and that “others will see that aquaponics is a viable form of sustainable agriculture.” (Jack Igisiar 2014).

Clearly, the goals of specialists are motivated not only by economic interest for the islanders themselves, but in the hope that Rota can serve as a model of sustainable agriculture for other communities around the world. In fact there has already been an interest in Western Samoa concerning the aquaponic initiative on Rota. This also speaks to the fact that while in its infancy, the project is already making an impact on islands with similar geographical vulnerabilities and dependencies (*Document, Email retrieved from the Rota Municipal Treasurer*).

Another motivation for the specialists is the reoccurring theme of improving health and the adequacy of food that comes from importation. With concerns over rising cancer rates and diabetes, the locals have a motivation for growing their own food in order “to see what is being grown, how it is grown”, and that the food is “chemical free.” (Harry Mendiola April 2014). This concern speaks to the idea that peace of mind is a

motivator when considering food security. Skepticism exists on the island due to the disconnect that exists between farmer and consumer of imported products. The research here suggests that by bringing the production of food right into the backyard of the consumers, the assured quality that is considered adequate and nutritious is guaranteed. This also suggests that one of the benefits of aquaponic food production is that it can bring food production to those that live on infertile or “marginal” land and would otherwise have to travel long distances in order to produce healthy food. By closing the gap of producer to consumer the aquaponic project seeks to provide a social benefit to the community in a multitude of ways.

Finally, personal economic motivations exist when considering commercial aquaponic food production. It came to light that members within the Rota team have goals of not only continuing to work with members within the community in order to proliferate the visibility and production of aquaponically grown food, but several also have plans to continue with the construction and production of their own aquaponic systems. I want to elaborate more on this topic when considering the section on commercial development within the final pages of this work in order to demonstrate the market potential that exist between Rota and neighboring islands of the CNMI. However, the point in addressing this is to show that the motivations for working on the grant project go beyond just temporary employment for some of the Rota team. It shows that the specialists believe in the overall mission of aquaponics, its viability as an alternative form of sustainable agriculture and the potential benefits that it can bring to individuals and to the overall well-being of the community. While this type of success is yet to be seen, what is visible is that those who have become educated on the system do

continue to believe in it on a personal level despite the eventual success or failure of the overall grant project itself.

In sum, concerns for the environment, the well-being of the community's health, peace of mind of adequate food, economic opportunities in the form of tourism and commercial export, supplemental contributions of food to the locals and simply the expansion of aquaponic as a viable form of sustainable agriculture are all motivators for those who have been educated and seek to educate others on the island about this most progressive form of food production. These motivations and concerns about aquaponic project reveal that the Rota Team expresses environmental, social and economic components which are vital to not only to the success of the project, but to the perceived enhancement of food security for the people of Rota.

Design and Implementation of Project Phases

The next section moves from the why question of the research to the how portion. This is important as it contributes to the case study aspect of my research. This "how" section elaborates upon two significant ideas- First, it unfolds the implementation of the grant design as a process of education, facility construction, and community outreach coupled with quantitative data that documents the costs and materials of each phase. Second, it demonstrates obstacles that the Rota Team encountered and how they resolved such issues along the way. This is important from the point of view of a case study in that others may learn from the inevitable frustrations that arise in a project of this nature while also giving concrete examples and advice of how to overcome many hurdles that the team has negotiated along the way. This portion also contributes to aquaponic

literature which argues that Rota as a model for food security for PICTs is demonstrating aquaponics as a potentially viable alternative to external dependency and food insecurity.

Phase I: Education and Training

Phase I began in January of 2013 when the Department of the Municipality selected five applicants from Rota and sent them to Olomana Gardens on the island of Oahu, Hawaii, for three months, as documented in the previous chapter. It was here that the Rota Team learned how to build, monitor, and maintain systems and become certified educators in aquaponics and permaculture. Interviews with four of the five were conducted (Calvo, Apatang, H. Mendiola and Igisiar).

Research indicates that three major aspects of this phase were crucial for the success, sustainability and continuity of the project on Rota: the academic classes that educated the team on the fundamentals of aquaponics and permaculture; the hands-on training in construction, design and maintenance; and the outreach portion where they were able to educate the public of Oahu on what they had learned. The Rota Team passed all requirements of the internship (Email retrieved from Glen Martinez to Frank Atalig April 2014) and took these acquired skills back to Rota where they were able to continue the next phase of the project.

Before the team could build or run any system they first had to learn the fundamental aspects of aquaponics and permaculture. They did this by taking an online certification course that was created by the University of Hawaii's Dr. Tetsuzan Ron. The program Aquaculture Teaching and Online Learning (ATOLL) is a curriculum designed to educate people in the theoretical and practical applications of aquaculture and permaculture. A portion of the curriculum involves aquaponics by Glenn Martinez, who

was also the team's instructor and the owner of Olomana Gardens. Each morning the team would study a portion of the course where they would take a test after each segment, which is a requirement of the ATOLL program. The team would complete this by noon each day (Apatang Interview April 2014), with the rest of the day devoted to hands-on learning of aquaponic systems (ibid). The Rota Team completed the ATOLL program within the first thirty days of their internship at Olomana Gardens and after such the rest of the time spent on Oahu was dedicated to the hands on application of aquaponics. After the completion of the course each member became a certified graduate and is recognized as an educator in the fundamentals of aquaculture and permaculture.

The hands-on training portion of the internship consisted of learning the functions of the aquaponic system at Olomana Gardens, maintenance and system repair all over the island of Oahu, and the construction of various aspects of aquaponic designs. Learning the system at Olomana Gardens was useful to the team in that it allowed for them to see first-hand the functions of aquaponics, and it allowed for them to practice system maintenance on an already existing system (Igisaiir April 2014). The Rota Team would feed the fish, clean filters, test the water for Ph levels and observe the overall functioning of the system. This allowed for the team to understand the workings of the system where they would use what they learned to "troubleshoot" and repair systems that have been installed around the island of Oahu (H. Mendiola and Jack Igisiar April 2014). This involved working with private individuals including institutions such as the University of Hawaii and BYU Hawaii as well. While this was important to passing the hands on portion of the internship it was not the most helpful in learning the most critical aspects of making Rota aquaponic project a success. The most important aspect of the three

month internship was being educated in a particular aquaponic design that uses an “airlift,” gravity feed, and bell siphon model (Igisair April 2014), which makes this project not only beneficial to the completion of the grant proposal but makes it sustainable and a more viable option to Rota’s most dependent upon state subsidies for food. The details of the system design will be discussed in the section that explains phase II, which highlights the importance of appropriate technology and food security.

The final detail that was important for the completion of phase I from the Rota perspective was for the Rota Team to become educators themselves. They were able to prove that they were capable of doing this by attending a science fair where they gave demonstrations of the design just mentioned above. The science fair gave the Rota team an opportunity to teach and demonstrate to the public, where all of the high schools on the island of Oahu were in attendance, the functions of the aquaponic system they were preparing to implement back on their home island. This was useful in that they were not only reinforcing the knowledge which was newly acquired, but they were explaining the workings of the system to an age group that is a desired target within their home population. Specifically, they were teaching the younger generation, which is exactly the demographic that needs to learn this type of farming if the goals from the government’s perspective are to be achieved (Igisair Interview April 2014).

Phase I was completed in just three months. The overall costs of this phase of the project was \$99, 375. There was originally \$121,511 allocated for this portion of the project, so the remaining \$22,136 was rolled into phase II of the grant funds. The costs of phase I consisted of airfare from Rota to Oahu, stipends for the Rota Team and tuition

fees for the internship at Oloman Gardens (*Grant receipts retrieved from the Rota treasurer*).

Phase II: Demonstration Facility

When the Rota Team arrived back on their home island in April 2013, they were not able to begin construction of the aquaponic facility right away. Delays in the supply of materials to the island that have already been mentioned prevented the team from implementing what they had learned on Oahu. What they were able to do was to begin clearing grass, weeds, and brush from the lot for the education and training facility and begin laying the foundation for the facility to be installed. Prior to the aquaponic system itself, the team had to use a variety of other skills in order to complete this preparatory portion of the phase. The team had to prepare the site for construction of the system, construct the system, and then continue with the aquaponic portion of the system and run it successfully in order to demonstrate that the project was not only a viable alternative for the community, but that they themselves had acquired the appropriate knowledge needed to maintain and operate an fully functional aquaponic facility.

Materials and purchases were not able to arrive until the summer months and continuing into the winter of 2013. Slowly as materials arrived the team was able to prepare the site and begin construction. The site for construction was strategically placed in between the two villages of Sinapalo and Song-Song in order to allow the public to view the site. There on the edge of Sinapalo, the 4 remaining members of the team and a few other members of the community now employed by the CNMI government began construction of the facility Frank Atalig Interview April 2014). On site was a gravel lot, a trailer used for material and tool storage, and a computer for administrative purposes.

The preparation of the site was laborious and demanded knowledge, skill sets and tools. Such tools include items such as a jack hammer, cement mixer, skill saw, circular saw, an electric drill and a chainsaw (*Document retrieved from Grant Manager Frank Atalig April 2014*). These tools were used to build the now existing aquaponic education and training facility. The skills that were used came from members of the community and members of the Rota Team. The skills used went beyond just the understanding of aquaponic systems and what is revealed is that for the initial workings of this phase great amounts of labor and construction skills are also necessary.

This section describes the design of the system and the costs of phase II. This is done in order that others might learn from the Rota model of how to address the costs of traditional aquaponic systems that use high demands of electrical output to move the water in these types of systems. This section is also important in that it demonstrates how an aquaponic system becomes viable for the consumption of food on a small-scale basis. This is because of a few factors including the construction of concrete for the demonstration facility, the use of air to move water and a design that feeds water back into the fish tank by the use of gravity.

By the end of the winter of 2013 and in to the beginning of 2014 the facility was constructed and the team began the process of growing food. What the team had constructed was a concrete system made up of a fish tank of over 2,000 gallons of water, three bio-filter grow beds of 33 sq. ft of room for growing food and three float beds holding the same amount of sq footage as the bio-filter grow beds. Additionally, there were two troughs of “duck weed,” a water fern that is grown as a protein supplement to the fish diet. While the choice of food that is grown consists of cash crops and some diet

staples, it is a process of trial and error that will determine the type of crops that are grown in the long-run. At the time of research, the system included okra, cucumber, string beans, chayote hot peppers, tomatoes, lettuce, and cabbage, not forgetting the hundreds of fish (*Fieldwork observations and document retrieved from Rota Treasurer April 2014*). While the system was still in need of certain materials and other inputs at the time of my arrival in early April, 2014, the system was already producing its second round of food as well as a continual supply of fresh tilapia.

The aquaponic system is made mostly from pvc piping and concrete. The pvc piping is used to move water and air through the system while the concrete is what the actual grow beds and fish tank are made of. This is the preferred material for the construction of this type of system, as it is the most sustainable considering the weather that Rota commonly experiences (Igisiar 2014). Rota is in the typhoon belt and experiences harsh rains and winds during the hottest months of the year. If the demonstration facility was constructed out of materials such as wood, then the life span of the facility would be greatly jeopardized (ibid.).

I myself saw the weakness of facilities constructed out of wood while maintaining and trouble-shooting systems on the island of Oahu. While working on the systems at Olomana Gardens and repairing the system at BYU Hawaii, I was asked to paint and repair rotten wood that was dropping out from the bottom of the grow beds. The work was laborious and demanded the use of power tools and time that could otherwise be avoided through different methods of construction. This is why the construction of the demonstration facility on Rota uses concrete. The concrete also provides an added benefit to the balancing of Ph levels in the fish tank because of the calcium that is present in the

concrete. This aids in cost reduction and improves the functionality and health of the environment within the tank. The use of concrete also eliminates the need to repair, replace or add water deterrents in the future which, again, is another cost saving mechanism in the Rota design.

The system that is used on Rota is a mixture of models that have been designed by various aquaponic specialists, resulting in what Mr. Atalig has said is “the most sustainable system for a project of this kind.” The system uses a blend of designs coming from Murray Hallam and Glenn Martinez. While most of what the Rota Team learned came from Mr. Martinez, what is shown is that the internship educated them in a number of aquaponic designs. The system on Rota uses the airlift model that has been developed by Mr. Martinez and the Hallam “bell” siphon for gravity feed. It was said in interviews that it was the combination of the airlift, the bell siphon and the use of gravity feed which makes this system a viable option for the locals on a small-scale (Igisaiir April 2014).

This particular design is unique in that it eliminates the use of a submersible water pump. The use of a submersible water pump is the most common type of method that is used in moving water from the fish tank to the grow beds and back to the fish tank again. However, when considering sustainable options for aquaponics this becomes problematic relatively quickly. This is due to a few factors, including but not limited to constant maintenance and repairs, the need of continual purchases for parts, increased labor and high energy costs (Fieldwork while interning with Glenn Martinez 2013). If using a submersible water pump the team would have to constantly monitor the filters, remove clogs and purchase new filters when they inevitably go bad (ibid.). This increases the maintenance and adds to residual costs of maintaining an aquaponic system. Moving

water with a water pump is not a low energy method of growing food aquaponically. In fact, it is because of the use of water pumps that the Rota Team acknowledged would threaten the viability of the entire project. The energy costs would outweigh the level of food production, resulting in a financial loss and material burden to the household (Igisiar April 2014).

However, the airlift model, which uses an air pump to move the water, reduces the cost to an almost invisible cost. As Jack Igisiar says, “the cost of turning on a light-bulb is what is used” (Saipan Tribune 2013). To make up for this, “just turn off one of your lights in the house and you don’t even notice electrical meter.” (Igisiar interview April 2014). The airlift also eliminates the use of filters, since the water is not traveling through any actual pump. The air is pumped externally and fed into the system so the water never moves through any type of pump. This eliminates the need to purchase filters on a continual basis, reduces labor in cleaning the filters and prevents any maintenance, such as a submersible pump needing repair or replacements of parts.

Added to the reduction of costs is the use of the bell siphon and gravity feed design. Here the grow beds fill up with the water that is airlifted into them, and when the water crests the top of the “bell” the water is siphoned out and pulled down into the lower level flow beds. Once the water is moved into the flow beds, they begin filling up to their desired level until the water is gravity fed back into the fish tank in a type of overflow method. With the use of the integrated design of the bell siphon and the airlift, this design uses one pump to move all 2,000 gallons of water in the system (Harry Mendiola Interview April 2014). By not using a traditional aquaponic model based on submersible water pumps, the Rota system is able to grow food with little to no electrical output thus

making aquaponics viable on the small-scale on an island that experiences high rates of electrical output (Thomas Mendiola April 2014).

The description of the system design is important for the purposes of this thesis in that it is because of the actual design and functionality of the system that this form of agriculture is a viable option for the majority of people on Rota. Without these cost saving mechanisms, aquaponics may not be a viable alternative for agricultural growth unless developed on the commercial level. In fact the research that I conducted while on the island of Oahu said just that (*notes from the Aquaponics in Hawaii conference held at Windward Community College May 2013*).

Costs of phase II consist of materials needed for the demonstration facility, salaries for the Rota Team and for the rental of equipment. Adding in all of these costs totals to \$105,601 from the months of August 2013 to April 2014. Combining this cost with that of the total costs of phase one, \$99,375, the project's first two phases add up to \$204,976. This means that \$64,353 of the grant's original \$269,330 remained (*Documents retrieved from the Rota Treasurer April 2014*). These two costs—education and facility construction—were necessary in order to for the locals of Rota to acquire the knowledge of sustainable aquaponic systems and to bring to the community a visible system that they could see working before making any commitment to build one of their own. The data also show that the remaining \$64,353 is all that is needed to develop 25 small-scale household systems (*Documents Retrieved from the Rota Treasurer April 2014*). This is important when considering that one of the main goals of promoting sustainable agriculture on the household level actually requires the least amount of funds and less than 13% of the entire grant (Ibid.). This means that in communities where

educators have already been trained and no demonstration facility is necessary for the promotion of community commitment, roughly \$64,000 is sufficient for the development of 25 household aquaponic systems.

Phase III: Community Outreach

This section aims to document the progress made thus far on phase III as well as discuss the community perspective which is critical to understanding how this project is viewed by those not involved in its inception. Phase III is yet to take full effect, and that has already been described as one of the limitations to this research. The main component of phase III is to get the community to take an active role in applying for an aquaponic system constructed by the team, learn the logistics and fundamentals of growing food aquaponically, and then purchase or construct their own system. How this is done is centered on education, hands-on demonstration, and a continual working relationship between the community and the trained employees of the DLNR who will take over the project once the grant funds have been exhausted. It is the intention that the systems as well as the knowledge will proliferate around the island and that some will be able to take up a commercial interest in aquaponic food production.

Public documents that I was able to acquire while doing my research on Rota state that 10% of phase III had been completed (*Document Retrieved from Frank Atalig Grant Manager April 2014*). During the course of the interviews with the Rota team, I was able to ask questions about this and what I found was that five individual systems had already been constructed, the Rota team had already built a functioning aquaponic system at the local aging facility and they have already given demonstrations to the local high school in an effort to educate the children on the value of aquaponic farming. What

the research shows is that the Rota Team is educating locals in all age groups, from children to the retired, that members within the community are optimistic about the project on a household level, and that some already are planning on investing in commercial-size systems. This shows that the project has the possibility of becoming successful in the long run even though this is yet to be seen.

The demonstration is intended to get the community members interested in asking about aquaponics. If they become interested, which some have, then they can apply for a system through the DLNR whereby they would receive a pre-constructed system. During the course of this time members from the Rota Team will visit and monitor the success of these systems. They will give advice on maintenance, pest management, harvesting of food and fish, and of course information on how they might purchase or build their own system (*Harry Mendiola Interview April 2014*).

For those who may not visit the demonstration facility, the Rota Team is actively reaching out to the community in order to promote interest. Jack Igisiar has visited the local schools where he gives demonstrations to the students. Mr. Igisiar thinks this is a good way to promote sustainable farming because “this younger generation is interested in technology and aquaponics can be the new technology for farming.” He also views this as an important way of promoting aquaponics because he says that some don’t really understand it until they can see it working, with the airlift pump and the gravity feed, but when they see it and they can put their hands on it, then they really like it. “That’s what’s good about aquaponics, it can teach those who need a hands on approach to learning.” This is an important factor if aquaponics is to have a sustainable presence on the island.

The Rota Team has also built a small system at the local aging facility. This system is like the residential systems that households will apply for. It consists of a 180 gallon fish tank and two grow beds holding roughly 32 lettuces and cabbages apiece. I was taken to this system by the grant manager and it was there that we discussed the potential productivity of the system. The aging facility can produce a small harvest every six weeks. If the food is rotated in three stages from seedling to juvenile to harvest, then the system will produce ten to twelve crops per week as well as 1-2 fish per week. The amazing thing is that this system only takes as much space as a sheet of plywood because the two grow beds are built vertically on top of each other. The system uses the mix of a gravity feed mechanism back to the fish tank and the airlift design to pump the water back into the beds (*Fieldwork April 2014*). Again, this system can easily supplement a family of four's diet on as little energy as it is to "turn on a light bulb." It should be noted that this system does not grow fish food, but with the proper composting system, which produces worms (vermaculture), they could feed their fish the proper amount of protein needed to maintain the system.

The systems that are being constructed for the community are just like the one that sits at the local aging facility. These system cost roughly \$1,500 to \$2,000 for materials and construction (*Harry Mendiola and Documents retrieved from the Rota treasurer April 2014*). This means that the 25 systems which produce enough food to feed a family of four will cost the project \$37,000 to \$50,000. This data reveals two main points that are pertinent to this research. First, that once there is a committed interest within a community, then \$50,000 at the most is sufficient to supplement the diet of roughly 100 people. The other point is that this portion of the project is the least

expensive of any phase and reiterates the claim that once the education portion of the project is complete, then the actual production of these food systems are relatively inexpensive. The potential of this amount of production at such costs will be discussed in the final evaluation and last section of the work.

Obstacles to Implementation of Phases II and III

I will now discuss the obstacles to the implementation of these phases in order to provide some insights into potential hurdles that must be made in order to make an aquaponic project of this nature become successful. While at the same time I acknowledge that this project is still ongoing and is not viewed as a success yet, the problems that the Rota team have encountered do provide a picture of what is to be expected when operating an aquaponic system. I will first discuss the obstacles of phase II followed by the solutions that the Rota Team has provided. I will then do the same with phase III, detailing perceived obstacles by the Rota Team and their predicted solutions that they are preparing to implement.

Obstacles and Negotiations to Phase II

There have been numerous obstacles all along the way. The obstacles can be expected due to the very nature of geographical isolation of Rota or any other PICT, and of aquaponics itself. The research here highlights the restraints to any agricultural development on a small island and to the issues that should be expected in aquaponic development, but it concludes with a wide range of solutions and contributes to the field of food security as some of the solutions are centered on sustainable and agroecological methods.

Obstacles to the development of the demonstration facility include creating the initial environment that is suitable for a productive system, pest management, dependence on electric supplies and electricity to maintain the system, and the delay in delivery of materials. Other obstacles exist when offering this study as a case for others to learn from if a project of this nature is to be successful. These consist of vulnerabilities to weather, the need for external inputs, off-island resources and the necessity of proper education of aquaponic management and maintenance. What is revealed here is that aquaponic food production has difficulties in achieving sustainable and viable operational functions, but there are solutions to these bigger hurdles some of which have been addressed in the work here and some of which are discussed in a recommendation portion of this work.

One of the most important components of beginning a functional aquaponic system is the introduction of plants and fish into the system at the proper time. If this is not done correctly then the system will not function properly, meaning your fish will die and your plants will not grow. This is exactly what happened on Rota in the first attempts of beginning their system. One of the few mistakes made by the team was that they did not introduce the fish into the system with the correct method. When the team had finished the construction of the system they immediately introduced the fish to the system “as soon as the cement had dried” (Igisaiir). This proved to be detrimental to the system as the result was that “90% of our fish died.” It was an expensive and tough lesson to learn, something that can take the motivation out of you, but the team did not

despair for long. What they learned was that they needed to allow for a method of “water transfer” if the fish were to survive in the system.

The proper method of water transfer is important and proved to be the solution to the massive die off that the team experienced. Water transfer consists of allowing the aquaponic system to cycle the water for a few days or even weeks. This is done to allow for bacteria to build up in the system that will eventually be the home environment of the fish. The team then transfers water from the system into the water where the tilapia are living before their introduction into the aquaponic environment. They then also take a significant amount of water from their existing environment and transfer it into the aquaponic system. In this way they ease the fish into their new environment. After only an hour or so, the Rota team introduced the fish into their system and all of their fish survived.

Another lesson that had to be learned the hard way concerns the system’s dependence on the electrical movement of water. As mentioned before, the Rota system uses a 40 watt air pump to move their water. This design of the airlift is essentially responsible for the viability of the system. “Without the airlift system this model would not be effective.” (David Calvo Interview April 2014). This has to do with the fact that electricity on the island experiences over “\$40 per kilowatt hours” of electricity and any other methods of moving water would be too expensive (*Retrieved from email sent to Merriam Fisher from Frank Atalig*).

The team also experienced a breakdown of their only pump and overnight they suffered a dying off of 1/3 of their fish (Igisiar, H. Mendiola and F Atalig 2014). This highlights two major vulnerabilities within the system: first, dependence on electricity;

second, the need to have back up materials like pumps and energy supplies becomes almost mandatory for the viability of such systems. While the Rota team is still working through these vulnerabilities there are still solutions to this problem they have taken. First, they have purchased a backup air pump in case they lose the one that is currently maintaining the system. This is wise because due to the nature of geographical isolation and the time delay in the delivery of materials; waiting months for a new air pump would mean that the entire survivability of the system was threatened. The backup air pump at all times reduces this threat and allows for the team to maintain the system in such instance.

A bigger threat on the island is its susceptibility to power outages due to the frequency of storms and typhoons. In the case of long-term power failure, the system begins to die off rapidly, losing everything in a matter of days. Solutions that exist to this vulnerability come from the internship that the team learned while on the island of Oahu. Backup systems exist in the form of gas powered generators and car batteries. If the system does have a good supply of gas and a generator that can run the air pump then they allow for days and in some cases weeks of maintaining the system without the electrical power coming from the local grid. In the case of running out of gas or in the case of not having a generator option the team can run its system by simply hooking up the pump to a car battery. This will give the system another few days of running due to the fact that the air pump system and design demand such little energy.

The fact that aquaponics is dependent upon electricity makes the success of the project very tenuous to say the least. The point is that even if members of the community are able to acquire the sufficient materials needed for a properly functioning system, what

can be said for those that once acquire such a system need to reinvest in the purchase of fish and plants if a systemic die off occurs. This vulnerability is highlighted here and is why solar is recommended as an important factor for the viability of aquaponic farming.

Other proposed alternatives to electrical vulnerability of the aquaponic system include the use of solar power and non-electrical methods of moving water. As mentioned before in the section of obstacles to the implementation of grant funds and reprogramming the local power company within the CNMI, the CUC has put a moratorium on new applications for solar hookups, thus making solar energy temporarily not an option. The choice to not use solar also allowed the grant recipient to develop the community outreach portion of phase III, whereby the Rota team is able to use some of the grant funds to build and monitor individual household systems. However, solar power is still a viable alternative for the further development of this project, especially because of the high amounts of sunlight within the CNMI.

Another option for reducing dependency on the electrical grid comes from research that I discovered and shared with Mr. Atalig. There is documentation discussing the use of hand powered pumps to move the water in aquaponic systems. These hand pumps are independent of any type of electrical use, only used 4-6 times a day, do not move water on a 24 hour basis, yet still grow enough food to feed a family (Perry and Rittgers 2004). While this is not a viable option on the commercial level, it makes perfect sense to invest in these types of models for individual household systems that are vulnerable to electrical power outages. This is exactly what I mentioned to Mr. Atalig during my time on the island and this more than piqued his interest. I have sent him the documentation of the hand pump model and Rota is open to using this type of method.

The Rotan vulnerabilities of environment and energy are legitimate and concerning when considering the catastrophic impact they can have on the viability of the system. However, the negotiations of these obstacles show that these vulnerabilities do not prevent an aquaponic system from becoming a viable alternative for sustainable food production and show the adaptability and resourcefulness of the Rota model.

One of the most immediate problems to the implementation of phase II has to do with pest management. No matter what type of agriculture there always seems to be the issue of pests, and aquaponics is no different. Pests are present on Rota and plague a few of the crops on within the system. Pests have diseased the plants and at times necessitated the removal of some of them and the restarting of the planting process. Pests can threaten not only the level of production but the viability of the aquaponic system to produce sufficient levels of food. However, the Rota team does not go so easily into the night. They plan on using a system of integrated pest-management that is based on the fundamental idea that an aquaponic farmer should not eradicate pests, but manage pests. As the project manager Harry Mendiola states in his interview, “You need to work with your environment in order to help you succeed, not destroy it which is what chemical pest control does.” (*Interview with Harry Mendiola April 2014*).

Pests do not affect every plant in the system, but for the ones that do the Rota model uses “integrated pest control management.” This integrated system means a variety of different approaches are used in order to reduce the level and even presence of certain crop threatening pests. The methods include intercropping, the use of “worm tea,” screens and lights. With a mix of these methods, said Mr. Harry Mendiola, the Rota

model emphasizes the importance of “using your environment to manage” your crops and avoid “destroying your local environment,” which in the long run is “unsustainable.”

Intercropping in the form of pest management is one of the best natural techniques that can be implemented without the need for any added inputs. The practice entails mixing a variety of crops in the same grow bed by either alternating crops within the same row or within every other row. The idea is that pests will not be able to damage as many crops as they would be able to in a single crop system (monocrop) because not all pests feed off of or lay eggs in every crop. However, this type of method is not foolproof, as some pests do have a wide range of plant preference and therefore can still damage a significant portion of one’s crops. The Rota team is still experimenting with what types of crops they need to intercrop and still learning what mixtures best fit their local environment.

While they are in this experimental stage they are using screens that they have built around some of their most affected crops. While this method does rely on keeping pests on the outside of the grow system, it does allow for minimizing damage while they incorporate other methods of pest control. The team also hopes to use lights in an effort to deter pests from approaching the crops at night. Since most pests feed on plants in the dark, the lights will be used as an effort to trick the pests into thinking that it is not time to feed or lay eggs. While this does add to electrical costs, it also demonstrates the facility’s technique of integrated pest control, which is meant to educate the locals on as many methods as possible which help make the aquaponic project a success.

One of the most effective and beneficial methods of pest control management that the Rota system uses, and one that exemplifies their system as an outstanding model for

sustainable agriculture, is the implementation of “worm tea.” Worm tea is an organic fertilizer, pesticide and plant nutrient all in one. The worm tea is made by using composting worms to create a soil from bio-waste. The soil that is made from the composting worms is put into a locally constructed “worm tea maker” that strains the nutrients out of the soil by water. The water that strains the nutrients absorbs all of the beneficial bacteria within the soil and is then applied to the plants and even directly into the system’s water supply. The worm tea is full of beneficial bacteria which keeps the plants strong and healthy. This is using nature at its best, since pests love to feed from the weak plants and avoid the strong and hardy ones (*Harry Mendiola April 2014*). Like a lion that hunts a gazelle, the pests only want to attack the ones that will be the easiest to take down. By adding the worm tea, the plants absorb added protective layer around their stalks and become essentially tougher to feed from.

While I was interning on the island of Oahu I attended a local aquaponic conference where the local research center CTAHR shared the added levels of nutrients into the plants that worm tea provides. . However, there are still some questions about the safety and food regulations concerning these methods employed into aquaponic food production (Klinger and Naylor). This concern of food safety is significant when considering that health and food safety is vital to food security. More studies are being done as to how nutritional and safe these methods of production are, but it has been argued that with good agricultural practices (GAP) aquaponics can offer a safe and healthy alternative to food production. (Aquaponics in Hawaii Conference 2013) .

What the negotiations of the obstacles to phase II demonstrate is that the Rota model has dealt with the obstacles of the construction and maintenance of their system in a pragmatic and environmentally sustainable way. The obstacles reveal vulnerabilities that arise in any aquaponic system, such as the dependence on a continual supply of energy and the concern of pests within the crops. By making adjustments to their methods they have shown that solutions to these vulnerabilities demand a pragmatic and agroecological approach. These methods are not only cost saving but highly beneficial to the system's functionality. Finally this section has revealed that the solutions to the inherent vulnerabilities of an aquaponic system can be dealt with in environmentally sustainable ways which contribute to the overall goals of reaching food security on Rota and help serves as a model for similar initiatives.

Obstacles to Phase III: Outreach and Community Perspective

In continuing with my main research questions of why and how aquaponics as an instrument for food security on Rota I felt it necessary to add a section on the community perspective. When interviewing locals about their perspective on the aquaponic project as an effort to promote food security, I wanted to talk to people that were not affiliated directly with the implementation of the project. This was achieved by working with Mr Atalig, who, again, put me in contact with members that were not directly affiliated with the project but had an interest in acquiring their own system. While the fact that it was the grant manager that put me in contact with these individuals and reveals a certain bias in this work, this in no way invalidates the responses to those within the community even though it may reveal certain concerns within the rhetoric of development in the social sciences. What it does highlight is that more research will need to be done in order to

better understand opposing perspectives and even counter arguments to the overall project as well. I was able to interview 3 individuals who were interested in both the household level and commercial level.

These interviews revealed an interest in aquaponics on cultural and economic levels as well as in its ability to produce healthy, locally-sourced greens which can contribute to the overall health of the community and aid in the reduction of dependence on imported foods. This section shows that aquaponics may be culturally appropriate for the people of Rota and in addition it shows that the interests of the community reflect similar goals of both the aquaponic specialists and those in the municipal government who initiated the project from the very beginning. This cohesion among scales is argued as not only being necessary for food security, but as a model that is necessary for the sustainability of any type agricultural development.

One of the most interesting topics that came up in the community interviews was how this type of agriculture is perceived on the island. I wanted to know *how* this system might work in the context of local's daily lives and *how* this might be accepted within the backdrop of a *culture* that is accustomed to catching salt water fish from the ocean and not fresh water fish from a small pond. The acceptance and willingness of the people of Rota to consume food in this way seemed to be an important idea concerning the success of the project regardless of the viable functionality of the system. In other words, I wanted to know if aquaponics on Rota was “culturally appropriate.” This section completes the “how” portion of my research in an effort to give a more clear picture of how aquaponics on Rota is perceived within the context of food security.

When looking into this question I found arguments for and against the local willingness to embrace aquaponic food production. The arguments for aquaponics centered around the desire to consume healthy and nutrient-rich vegetables, and interestingly the idea that aquaponics was circular in its very nature. The arguments against aquaponics consisted of a lack of desire to consume fresh water fish, as this seemed foreign to custom. The islanders on Rota value the fish that comes from the ocean and, in their view, it simply tastes better. Some that I talked with almost snarled at the idea of consuming fresh water fish instead of salt water fish. This may be a barrier for the goal of selling commercially within neighboring islands. If the people are unwilling to consume tilapia, then the aquaponic system may lose some of its potency in being able to provide an increased production of protein to the diet. This is why further research needs to be done in order to better understand how the overall community perceives the consumption of freshwater fish which is further discussed in the recommendation section of this work. On the other hand, while it seemed to depart from custom, others showed an increasing interest in the consumption of fresh water fish and its ability to be raised and harvested right in one's own backyard. Also, if fresh water fish is not the preferred food, there still exists the production of chemically free produced vegetables. Overall, this does not seem to be a significant obstacle to the overall project due to the fact that aquaponics also produces vegetables, but is worth noting when considering the impact of a small yet significant change in diet among fishing communities of the Pacific.

This also was a concern that was mentioned while I was interning in Hawaii. There I went to a meeting of local aquaculture and aquaponic producers who were

attempting to form a co-op and stabilize a profitable price for tilapia on the island. The meeting was attended by members of CTAHR and Hawaii's department of Agriculture. During this time some mentioned renaming the fish in an effort to promote its consumption. Others disregarded this as an old tactic and that rebranding the fish as healthy and tasty was the only way. In either case, this reveals that one hindrance to aquaponic food production may be the lack of desire to consume its most viable fish, tilapia, and it shows that the consumption of fresh water fish is not necessarily culturally desired. However, this says nothing about the desire for fresh vegetables, which can be consumed even if the fish is not.

Arguments for aquaponics focused on its nature as a recirculating system. One interview revealed that this recirculating system was very appealing in that it reflected a traditional component of interacting with the local environment. I learned that traditionally the people of Rota interacted very respectfully with the sea and plant life. Hunting practices allowed for the continuity of the harvest. For example, when hunting for fish, if the locals would catch a pregnant fish, they would return it back to the water. If someone on the island did not follow certain rules, then the rest of the islanders would essentially shame him and anyone who was thought to have hunted with him (Thomas Mendiola Interview April 2014).

There is a level of pride and honor for the men who can go to the ocean and catch fish. When men bring food back to their families and friends they are respected in the community. If a hunter is particularly good at catching a certain type of fish, traditionally people on the island would give that man (or even his family) a nick-name relating to the

prey. If someone was good at catching Skip-Jack, a local fish, his name might become Skip-Jack Frank, for example (*Thomas Mendiola Interview April 2014*).

This public pride and shame in connection with hunting practices has helped contribute to an overarching idea of balance and harmony with the environment. This respect of what the ocean provides is a part of the culture on Rota (*Thomas Mendiola Interview April 2014*). While research shows that today some of these traditional customs have eroded due to lack of teaching the younger generation, immigration, EPA regulations which disrupt traditional hunting practices, technology in the form of refrigeration and “lack” in ability “of law enforcement” to ensure resource protection (*Ricardo Barcinas Interview April 2014*) it also shows that the value of harmony and balance is still very important to the survival of culture and life on the island. It is for this reason that during my interviews one man said that he was very interested in what aquaponics has to offer the people of Rota because as a system based on the harmony between fish and plants, aquaponics is a very interesting concept to him. He believes that it is this level of sustainability that others will be able to relate to, as well. For any project of this nature to be sustainable, the people need to have a connection that they can personally and culturally relate to, in order to give them a sense of ownership of the overall project which does not feel so foreign to them. In effect, while aquaponics is a newer type of agriculture, its fundamental components reflect a certain type of environmental harmony that has traditionally been a part of everyday life on the island of Rota.

Members within the community also expressed an interest in aquaponic based on concerns for health. One woman that I interviewed was particularly concerned with an

increase in cancer rates on the island. She mentioned that she noticed a considerable increase within the last thirty years. One of her fears is that this may be due to the fact that the food that is coming into the island is produced by chemical agriculture (*Tanya King Interview April 2014*). While there is no direct evidence that suggests this, the fear of disease due to imported food reflects a state of food insecurity. Aquaponics, with its ability to ensure chemical free production, in close proximity to those consuming it, eliminates this fear and provides a type of food security on the local level. However, the importance of good agricultural management is very important for the success of aquaponic food systems. If managed incorrectly, aquaponic systems can also be dangerous to those consuming it. Further research and regulation will be needed if more is to be better understood on how the negotiations of these obstacles are to be achieved.

There is also great motivation for commercial aquaponics on Rota. I interviewed a businessman who is planning on building a commercial-size system. One of the biggest motivations for wanting to produce food aquaponically, he said, was “Simple. Food security.” When asked whether he felt there was a need for locally produced vegetables on the island, he said, “Restaurants are in dying need, stores are in dying need. Everything has to be flown in or shipped in. With aquaponics we reduce our dependence on imported foods and we produce them right in our own backyard.” (Norbert Mundo Interview April 2014). Aquaponics and the need for affordable locally produced food affordably has inspired Norbert to seek agencies involved in property and system design as well as farm service agencies. As he develops his commercial system he hopes others will develop their own as well. In this way he sees the island becoming less dependent on imported food while promoting a local market.

We also discussed why he thought that this system was more viable than other alternatives to food production. His answer was “With traditional farming you are controlled by time and money. With aquaponics you have more of both. . . . This is because aquaponics is less-labor intensive and with the reduction of costs of inputs, it becomes a better option. In traditional agriculture one needs to spend \$30,000 for a tractor.” (Norbert Mundo Interview April 2014). The costs become even greater when considering transport repairs, costs in parts and gas. Tractors break down and need maintenance. With aquaponics, you eliminate the costs of repairing so many manufactured parts. Again, “this saves you time and money.” The low cost and the reduction in labor has proven to be an incentive on the community level. Thus, one of the goals of the municipal government of Rota for achieving food security--to promote commercial development in aquaponics--has already made an impact in the community.

On the household level there is a great interest in the systems as well. It is common on the island for people to have their kitchen outside and, in some cases, right in their backyard. It is also very common, if not an everyday practice, for the people of Rota to eat with extended members of the family and friends. Eating is a very collective function on Rota and is a part of the everyday culture and island identity. While on the island I was fortunate enough to eat and congregate in several of these outdoor kitchens. One interviewee mentioned how fitting a backyard system would be to have it right next to his outdoor stove. He imagines having friends over and picking vegetable from his system and pulling a fish right out of his aquaponic tank and “frying it up right there” for his friends and family. This interest on the household level shows that the educational goals of the local government are already making an impact. Success, which in the view

of Frank Atalig is “when we see systems in people’s backyards” can only be achieved if the interest is there among the people. This research shows the interest is not only there but seems conducive to everyday life on the island.

In concluding the section on the community perspective, what is revealed is that the goals of those who initiated this project seem to be having an impact on some of the people on Rota. The impacts are evident among younger individuals such as Jack Igisiar, who is only 23 and is one of the main proponents of the project. Members within the community show an interest in the individual household system that is necessary in order for phase III to become a success. Research shows that there are already individuals on the island who are investing, learning and making plans on a commercial scale for development of aquaponic systems. The motivations among people show an interest in providing food for themselves and others. They show an interest in growing food that is healthy and locally produced. Among locals, the cost and time involved in starting aquaponics is viable and is not hindering the development of systems on a commercial level.

Thus we see that the motivations and goals of aquaponic development among members of the community reflect the goals and motivations of the initiators and creators of the aquaponic project. The goals and motivations of those embracing aquaponics reflect a concern and action towards food security on the island within members of the community. Thus, this section reveals aquaponics is not wholly rejected by members within the community and in at least some cases is creating an interest albeit if only on the surface level. This also shows cohesion between those who are implementing the project and those it is intending to benefit.

Final Analysis of the Rota Aquaponic Project

Review of Research Questions

This work has attempted to answer two overarching questions related to the development of small-scale aquaponic production on PICTs as a viable agricultural system for food security:

1. Why Aquaponics as a Method to Ensure Food Security?

Research has shown that aquaponics addresses preexisting issues concerning agricultural development on the island. Motivations include promoting new generational farming practices that are less-labor intensive than traditional agriculture, improving access to growing food by bringing agricultural production to the individual household level that is more affordable than existing alternatives, promoting environmentally sustainable alternatives to current farming practices, producing healthier foods, promoting both a domestic market and, potentially, a market for commercial export. All of these are attempting to achieve one of Rota's main goals: becoming more of an independent territory from the mainland U.S. by reducing its dependence on external imports. All of this is motivated by a people who are culturally proud and look to stand on their own in dignity. They have sought to do this through aquaponic food production.

2. How Does Aquaponics Address Food Security on Rota?

Islanders are accomplishing this goal in a variety of ways. First, they have used available federal funds in the form of a grant to kick start the food security experiment. They have used the funds to empower the members of the community through education

to understand aquaponic and permaculture theory and practice. Through the construction of the demonstration facility, they have moved from a theoretical argument to something concrete and visible in order for the community to become convinced of the viability of the project. Second, they have created a type of syncretism between the local municipality and community members through the community outreach portion of the project. This acts as a form of continuing education for community members and ensures the continuity of the project as the DLNR works to answer any questions that individuals may have about their aquaponic systems along the way. Third, they have been adaptable and resourceful throughout the entirety of the project. Delays and lack of materials have stalled the project at times and it has been the deep commitment of the project workers to never become too discouraged or give up that has made this project work thus far. The resourcefulness of the workers and community support has buttressed the project where it would otherwise have not been able to continue.

In answering both these research question this thesis seeks to argue that aquaponics has become a viable alternative for food security on Rota and can contribute to the food security initiatives of neighboring and far removed PICTs as well.

Contribution to Literature

This thesis hopes to contribute to academic literature in several ways. First, I hope to add to literature of food security for PICTs. While there are currently aquaponic projects being done in Pacific Island Countries and Territories which are focusing on promoting food security, there is no other case study to date that documents a local municipal government initiative to promote overall island independence from food imports on a subsistence and commercial level. This case study is also unique in that it

proposes an educational component between the state and individual households in order to promote community independence from external forms of food dependence.

Second, I hope to advance the argument for small-scale aquaponic systems in two ways. First, I argue that aquaponic food production is promoting an interest on Rota as potentially a viable alternative to food production. . Second, I argue that members within the Rota community seek to accomplish an aquaponic food security projects through the development of small-scale aquaponic systems. is now being While aquaponics has emerged in response to the increasing need of sustainable agriculture to address the food security crisis there has been no actual case study that demonstrates a government-to-community-based solution to food security through aquaponic production on its own initiative free from external development agencies. Rota sought this project out from its own research and desired the production of aquaponic systems as it seemed to fit within its geographical, environmental and cultural context. I also hope to argue against those who make the claim that aquaponics is only a viable option on a large-scale and commercialized level, which is the most commonly read argument in aquaponic literature and conferences today.

Finally, I hope to appropriately fit aquaponic food production into the literature of agroecology and food security. Agroecology has emerged as the most important component of food security and environmental sustainability. It has been argued that agroecological principles must be incorporated into food security initiatives if they are to be successful, and I have introduced aquaponics as a subset of such principles (Altieri 2012). It has been from the efforts of the people of Rota that we know this argument to

be more valid than simply making a theoretical claim to the importance of aquaponics and food security.

Limitations of Study and Lessons Learned

The limitations which exist in this study have to do with time and the scope of the research that I conducted while on the island and the very shortcomings of aquaponic production itself. Shortcomings of the project consist of dependency issues. Dependency exists concerning electricity, external inputs, materials, and the need to have trained individuals who can manage these systems.

First, the project is still in its last phase and has yet to be complete. The completion of the grant project is not set to be complete until November of this year, and even then the DLNR will only be beginning its involvement of educating and interacting with the community. This means that there is still much time that needs to pass until anyone can say whether or not the project is a success.

Second, limitations exist within the time constraints and scope of my research interviews. While I have been studying aquaponics for three years now and have travelled across the Pacific Ocean twice to learn both the theoretical and practical applications of aquaponics, I still was only able to spend eleven days conducting interviews on the island of Rota. This undoubtedly highlights the inability to interview a large number of people on the island. This makes it difficult if not impossible to give an accurate portrayal or complete representation of what motivations and concerns the people of Rota have about improving food security. This limits my scope to thirteen different interviews which I have presented in the form of three different perspectives based on the criteria of connection with the project. In the case of conducting future

research, I would like to interview more people who do not have a connection or already existing interest in aquaponic food production. The fact that most, but not all of the people interviewed already had a vested interest in the project reveals a certain bias, but it does not invalidate the concerns and goals presented in this work.

Other limitations exist when considering the very nature of aquaponic systems. These limitations have to do with whether or not aquaponics has the ability to address the concerns it sets out to achieve. This includes that fact that aquaponics needs capital, external inputs such as fish food and electricity. The need for external inputs highlights the continued need of financial inputs and thus, the vulnerability of the system. This means that the aquaponic project is limited in its ability to benefit everyone in the community and has the potential to only benefit those in the community who already have access to investment levels of capital. This is problematic when considering the literature on access and food security.

The fact that aquaponic systems need to be managed by trained individuals has been documented as being essential to its success. Those that seek to sell the idea of aquaponic management without the proper training have been recognized as a threat to the continuity of aquaponics and have been dubbed as “aquashysters.” (Goodman 2011). The need to have trained and educated specialists demonstrates that the success of this project is dependent upon the sharing of knowledge and continued training of community members. While this has been acknowledged by the project designers, this has yet to be seen as this project is just beginning to enter its final stage and is yet to be seen. This reveals a significant vulnerable component to the success of this project and highlights another level of dependency in the project. The dependency on trained and educated

individuals should be acknowledged by any other groups of people attempting a project of this nature.

While the limitations in time and scope reveal a certain level of incompleteness of the argument presented here, it should be noted that this project is still ongoing and there is still a lot to learn. There is much to be learned in how this project will impact the community and what further adaptations will be made in order to make it a success. There is much more available research to be done concerning aquaponics and food security among PICTs. It should also be noted that this project is only a little over a year old and, since it is the first of its kind, this makes it a work in progress not only for members of the Rota community to learn from, but for everyone else interested in such initiatives on all scales.

Rota as a Potential Pathway to Improving Food Security

It is the hope of the project designers that this project can not only be successful but can serve as a potential model for neighboring PICTs and food dependent communities around the world by promoting the use of aquaponic food production. Aquaponics is an important contributor to food security not only for Rota but for every other community that lacks the soil needed to produce healthy greens and that wishes to reduce its dependency on agricultural imports. While it is still to be seen how such a system of food production can make an impact among the world's most destitute, it becomes an option for those who have access to financial grants and who wish to promote community empowerment through education and agroecological means.

Rota has created a sort of bridge-building initiative between state and community, whereby the state eventually moves to the wayside and the community is

able to continue the functionality of the project on their own. This addresses the immediate concerns within the community as well as simultaneously opens the door for economic advancement by allowing some to enter the market or even create a domestic market of food production. In these ways, Rota hopes to make an impact on neighboring islands and become a potential model for others to follow as it takes the lead in an experimental agricultural system as a viable form of alternative agriculture.

It can be argued that Rota is trying to provide an example by offering up an experimental step towards food security through aquaponic production. As steps continue to be taken neighboring islands can learn directly from the Rota project designers themselves concerning the project. Mr. Atalig has already been contacted by an extension agent connected with the ATOLL program on the island of Oahu. There is also an interest in aquaponic production coming from Western Samoa (Email retrieved from Rota treasurer). People from Samoa have contacted aquaponic specialists on Oahu and have sought to connect with members of the Rota community in an effort to learn about the process of implementing aquaponics on their island. Due to the fact that Western Samoa is also a PICT, a territory of the U.S., and has access to federal grant dollars, the Rota model is almost a perfect match for a Samoan aquaponic food security initiative. While this is yet to be implemented, what is certain is that the Rota initiative is known about on Samoa and has sparked an interest on the neighboring island as well. This means that the Rota project has already made an external impact in promoting food security through aquaponics. Whether every method or practice is followed on Samoa or not, others can still learn from both the obstacles and solutions from the Rota project presented in this work.

Recommendations

There must be further study into the community if more understanding of how aquaponics can actually benefit Rota. Because of the limited number of interviewees, this thesis cannot argue that aquaponic food production is the most viable pathway to achieving food security. In order to address this issue some recommendations have been made in order to further understand how researchers might further understand the views of the community.

It is recommended that further research be done in a way that emphasizes the voices of the community so as to better understand what concerns exist when discussing aquaponic food production. In an effort to do this I suggest something like a democratic community survey be done about what the community thinks about other pathways to improving food security. Some questions should focus on what hindrances materially or culturally exist which would disenchant the community from engaging in aquaponic food production. This should be done with a focus on familie and incorporate the perspectives of women within the community. This recommendation emphasizes not only the limitation of the research revealed in this thesis, but highlights the significance of the community perspective which is underrepresented in the work provided here.

There should also be a heavy focus on the topic of what food is desired to be grown on a local level. This brings up the question of whether or not the food that is produced in aquaponic systems is even desired by members of the community. This is important because while the project is growing food on an experimental basis in order to see what crops fair well in the Rota climate, there needs to be more data on what the community itself would desire to grow despite the production of food aquaponically.

This came up in interviews where there was a certain unfamiliarity with freshwater fish. As a fishing community of the Pacific ocean there must also be more research concerning the perspectives of freshwater fish production may have within the community. This highlights a significant point in addressing other potential pathways to food security which this thesis did not and cannot fully address.

Final Conclusions and Future Goals

Aquaponics on Rota has the potential to address food security in a variety of ways, which include the local production and consumption of healthy, chemical-free food, environmentally sustainable methods that represent agroecological principles of food production, reducing potential harm to the community from imported foods, increasing the production of food among Rota's younger generation, reducing the island's overall dependence on food imports, and, finally, creating a commercialized market for export to neighboring islands. The variety of benefits that Rota has sought to achieve through aquaponics represents a multidisciplinary and post-modern approach to achieving food security and demonstrates Rota's forward thinking approach to addressing its dilemma of ecological abundance yet lack of access to resources. Rota is attempting to address this dilemma through aquaponic production.

In understanding how the Rota Team is attempting to address food security, what has been shown is that the project has been guided by a multi-scale relationship on the federal, local municipality, community and individual level. From the acquisition to the implementation of grant funds, a direct dialogue has taken place from each scale and has allowed for appropriate adaptations to be made in response to obstacles that have been

encountered through the course of the project. The current level of progress that has been made is based on an emphasis of education in aquaponic agriculture which is currently proliferating on the island, thus expanding knowledge and encouraging those with sufficient resources to invest in the commercialization of aquaponic food. It is the argument presented here that with all its successes, hindrances, and adaptations along the way, the Rota aquaponic project has already begun serving as a viable model for food security among PICTs and, potentially, future development initiatives around the world.

APPENDIX

INTERVIEWS

Atalig Fermin- Committee member for the federal technical assistance grant, personal interview 2014.

Frank Atalig- Grant Manager of the Rota Aquaponic Project

David Atalig- Campaign Manager for Mayor Mendiola of the municipality of Rota
Personal Interview, April, 2014.

Jack Igisiar- Aquaponic Specialist, Recorded Interview April, 2014.

Harry Mendiola- Project Manager and Aquaponic Specialist, Recorded Interview April
2014.

Ricardo C. Barcinas- Retired Rota police Lieutenant and local member of the Rota
community, Interview April 2014

Jimmy Apatang- Aquaponic intern, personal interview, April 2014.

George Hocug- Elected Official, Recorded Interview April 2014.

Norbert Mundo- local businessman, local member of the Rota community and retired
U.S. military, personal interview April 2014.

Tanya King- local member of the Rota community redorded interview April 2014.

Thomas Mendiola- Advisor to the Mayor, Recorded Interview April 2014.

Songsong Ayuyu Nicolas- Resident Director of the Department of Lands and Natural
Resources, recorded interview April 2014.

Calvo M. David- DLNR employee and aquaponic specialist, personal interview April
2014.

Melchor Mendiola- Mayor of the Municipality of Rota, Interview April 2014.

REFERENCES CITED

- Adams, T., Bell, J. and Labrosse, P. Current status of aquaculture in the Pacific Islands. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. *Aquaculture in the Third Millennium*. “Technical Proceedings of the Conference on Aquaculture in the Third Millennium”, Bangkok, Thailand, 20-25 February 2000. pp. 295-305. NACA, Bangkok and FAO, Rome. 2001.
- Ahmed, Mahfuzuddin. Lorica, Mylene, Improving Developing Country Food Security through aquaculture development: Lessons from Asia, *Food Policy*, 27, 2002.
- Altieri, MA. Agroecology: A New Research and Development Paradigm for World Agriculture, *Agriculture, Ecosystems and Environment*., 27: 37-46. 1989.
- Altieri, MA. Agroecology: the Science of Natural Resource Management for Poor Farmers in Marginal Environments, *Agriculture Ecosystems and Environment*, 93, no. 1-3, : 1-24, 2002.
- Altieri, MA. Conversion Agroecologica de Sistemas Convencionales de Produccion: Teoria, Estrategias y Evaluacion, *Ecosistemas* 16 (1): 3-12, 2007.
- Altieri, MA, Munzote and Peterson,. Agroecologically Efficient Agricultural Systems for Smallholder Farmers: Contributions to Food Sovereignty, 2011.
<http://agroeco.org/wp-content/uploads/2009/11/Altieri-Funes-Petersen-Palencia.pdf>
- Australian Government Report,. “Food security in the Pacific and East Timor and its Vulnerability to Climate Change,” 2013.
http://aci.gov.au/files/node/14932/tr080_food_security_in_east_timor_papua_new_guin_11355.pdf
- Bell, J. Reid, C. Michael, Betty. Et. al. Effects of Climate Change on Oceanic Fisheries in the Tropical Pacific: Implications for Economic Development and Food Security. *Climatic Change* 119:199–212 DOI 10.1007/s10584-012-0606-2, 2013.
- Bello Walden, Mara Baviera. Capitalist Agriculture, The Food Price Crisis and Peasant Resistance, (Found in Wittman Food Sovereignty), 2010.
- Belsare, Satyajit. Aquaponics: The Food Production System of the Future, *InfoFish International*, Vol. 4; July- Aug. pp.8-1, 2007.
- Bernstein, Sylvia. Aquaponic Gardening : A Step-by-Step Guide to Raising Vegetables and Fish Together, Gabriola, B.C. : New Society Publications, 2011.

- Bolick, Clint. "Human Events". 04/18/97, Vol. 53 Issue 15, p20. 3/4p. 2 Black and White Photographs
- Carolan, Michael. *Reclaiming Food Security*, Routledge, 2013.
- Carr, Edward. Postmodern Conceptualizations, Modernists Application: Rethinking the Role of Society in Food Security, *Food Policy* 31, 2006.
- CIA - The World Factbook -- Northern Mariana Islands. CIA World Fact Book, 02771527, 2008
- Dilley, Maxx ; Boudreau, Tanya E. "Coming to terms with vulnerability: a critique of the food security definition", *Food Policy*, Vol.26(3), pp.229-247. 2001.
- Driver, Marjorie. *Cross, Sword, and Silver: The Nascent Spanish Colony in the Marianas*. 1990.
- Emerick, Richard. *Land Tenure Patterns: Trust Territory of the Pacific Islands*, The Office of the High Commissioner Trust Territory of the Pacific Islands. Guam, M.I. (pp.242-245), 1958.
- Fairbairn, Madeleine. *Framing Resistance: International Food Regimes and the Roots of Food Sovereignty*. Oakland, CA. 2010.
- Food and Agricultural Organization of the United Nations (FAO), *World Food Summit; Rome Declaration on World Food Security and World Food Summit Plan of Action*, Rome, 1996.
- Food and Agricultural Organization of the United Nations (FAO), "Climate Change and Food Security in Pacific Island Countries" p. 135, Rome. 2008.
- Gibson, Mark. *The Feeding of Nations: Redefining Food Security for the 21st Century*. CRC Press, 2012.
- Gliessman, Stephen. *Principles of Agroecology*
http://agroecology.org/Principles_Def.html
- Goodman, Elisha. *Aquaponics: Community and Economic Development*, Thesis: MIT, MA. 2011.
- Hezel, Fr. Francis. *From Conquest to Colonization: Spain in the Mariana Islands 1690 to 1740*. NY, 1989.
- High Level Panel of Experts on Food Security and Nutrition, "Sustainable fisheries and aquaculture for food security and nutrition" June, 2014. www.fao.org/3/a-i3844e.pdf

- Hillyer, C. Is Aquaponics the Agriculture of the Future? *International News on Fats, Oils and Related Materials* : INFORM; Feb; 18, 2; ProQuest pg. 83, 2012.
- Hollway Wendy., Jefferson Tony.,. *Doing Qualitative Research Differently: Free Association, Narrative and the Interview Method*, Sage. NY 2000.
- Ibanez y Garcia, History of the Marianas, with Navigational Data, and the Caroline, and Palua Islands, University of Guam. 1992.
- Kent, George. Fisheries, “Food Security and the Poor”. 1998.
- King, Gary. , Robert O. Keohane, & Sidney Verba. *Designing Social Inquiry: Scientific Inference in Qualitative Research*, Princeton University Press. 1994.
- Kittinger, John. Human dimensions of Small-Scale and Traditional Fisheries in the Asia-Pacific Region. *Pacific Science*, vol67, no. 3, P315 2013.
- Klinger, D. Naylor, R. Searching for Solutions in Aquaculture: Charting a Sustainable Course, *Annual Review of Environmental. Resources.*, 37: 247–76. 2012.
- Lang, Tim. Barling, David, Food Security and Food Sustainability: Reformulating the Debate, *The Geographic Journal*, Vol. 178, No. 4, 2012.
- Maxwell, Simon. Food Security: A Postmodern Perspective, *Food Policy*, Vol. 21, No. 2 pp.155-170, 1996.
- Mecki Kronan, Aliti Vunisea, Warwick J Nash et al. “Planning the use of fish for food security in the Pacific”. *Marine Policy*, 2008.
- Mecki Kronen, AlitiVunisea, FranckMagron, BrianMcArdle. “Socioeconomic Drivers and Indicators for coastal artisanal fisheries in Pacific Island Countries and Territories and their use for fisheries management strategies.”, *Marine Policy* 34 1135–1143. 2010.
- Mollison, Bill C. *Permaculture: A Designer’s Manuel* 2nd Ed. *Australia*. 2004.
- Neher, D. Ecological Sustainability in Agricultural Systems: Definition and Measurement. *Journal of Sustainable Agriculture*, Vol 2. (3), pp.51-61. 1992.
- Nichols, M.A. *Aquaponics: Protein and Vegetables for Developing Countries*, *Acta Horticulturea*, Vol. 95: 8, 189-194. 2012.
- Perry April, Rittgers Sheila. “Aquapoincs in Haiti’, *Aquaponics Journal* issue 34, 1st quarter. 2004.

- Putnam H. Godek, W. Susanne Kissmann, Jean Luckson Pierre, Santos Humberto Alvarado Dzul, Hector Calix de Dios, Stephen Gleissman., “Coupling Agroecology and PAR to Identify Appropriate Food Security and Sovereignty Strategies in Indigenous communities”, *Agroecology and Sustainable Food Systems*, 38: 2, pp. 165-198. 2014.
- Rakocy, J.E., Lasordo, T.M. and Masser M.P., Recirculating Aquaculture Tank Production Systems: Integrating fish and Plant Culture. *SRAC* No. 454, 1992.
- Rocha, Cecilia, (2008) Building Capacity in Food Security, Center for Studies in Food Security, Brazil.
- Secretariat of the Pacific Community, “Food Security in the Pacific and East Timor and its Vulnerability to Climate Change” Noumea, New Caledonia, 2011.
- Silcox, Dane. (2013). “Aquaponics as a Sustainable Urban Business Model”, A Thesis published under Central Connecticut State University, Connecticut.
- Smith, M. Pointing, J. and Maxwell, S, Household Food Security: Concepts and Definitions: An Annotated Bibliography, *Brighton Institute of Development Studies*, CA. (1993).
- Tenorio, Pedro. (2006) CNMI Congressional Records Concerning the Current State of the Northern Mariana Islands
- Wittman, Hannah. Annette Desmarais and Nettie Wiebe., The Origins and Potential of Food Sovereignty (Found in Food Sovereignty) Oakland, CA. (2010)..