THE OHIO STATE UNIVERSITY

Aquaponics: Bring Home a Fishing Hole

Business Plan Handbook

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The Team

Business Team
All students at The Ohio State University Fisher College of Business:
Brandy Alexander - *Senior Accounting Major, Economics Minor*
Kat Dickey - *Senior Accounting Major, Spanish Minor*
Nate Roberto - *Senior Finance Major, Engineering Minor*

Business Advisor
Dr. Judy Tansky is an Ohio State Alumni who has 20+ years of experience teaching entrepreneurship and humanitarian business at Ohio State. Her areas of expertise include managing people in small and entrepreneurial firms. Brandy and Nate have worked closely with Dr. Tansky through the Fisher Honors Contract Program focused on non-profit consulting.

Engineering Team
Jeremy Shechter - *Senior Agricultural Engineering Major*
Jeff Thaler - *Senior Agribusiness and Applied Economic Major, Engineering Minor*
Liz Roche - *Plant Pathology Major, Engineering Minor*
Peter Boyer - *Masters of Electrical Engineering*, projected May 2014

These students have a wide array of experience related to engineering as well as agriculture. Jeremy has extensive prior experience with aquaponics over the last couple of years including pursuing his interest as a career path upon graduation. Jeff is very experienced in CAD design and Liz will focus on optimizing the grow bed yields. This experience enables the team to make sound design modifications in order to improve durability and cost effectiveness of the system.

Overall Project Adviser
Dr. Howard Greene is advising primarily the engineering team but also serves as the overall team advisor. Howard holds his Master's and PhD from Ohio State in Electrical engineering and was a project manager at Battelle for a few years as well as now working for The Ohio State University on collaborative programs. Howard has extensive travel experience to Honduras including a connection with Honduran missionaries, Larry and Angie Overholt, who have been serving in Choluteca for over 25 years.

Management Team
Overseeing the high level operations of the business will be Larry and Angie Overholt of World Gospel Mission (WGM). They have established a positive network among potential customers from numerous rural villages surrounding Choluteca, Honduras as well as government officials in the area. The Overholts will give operational oversight to two of their local workers, Chacho and Hebert, who have over 20 years of experience with construction, procurement, and the local community. They will oversee the installation of each unit and will be the main points of contact for further purchases, supplies, and repairs. Moreover, WGM will be responsible for allocating the seed fund through to the village (See Financial Summary).

Problem Description

In many developing parts of the world, food security is one of the most prevalent concerns with respect to human health and nutrition. According to the World Health Organization (WHO), malnutrition is the gravest single threat to global public health and is by far the largest contributor to child mortality[1].

Honduras, a country of 7.5 million people, is the second poorest country in Central America[2]. The gross national income per capital is roughly 2,000 USD per year[3]. Siete de Mayo, the initial start-up location for this aquaponics business, is a rural village a few miles outside of the city of Choluteca in southern Honduras. Dietary insufficiencies are primarily a lack of micronutrients and protein due to the insecurity of food.

Honduras is also one of the most vulnerable countries to natural disasters in the world and extreme weather conditions frequently contribute to the issue of food insecurity. Hurricanes can wipe out existing crops and prevent access to food and other basic necessities. Wet and dry seasons coupled with mountainous terrain limit the harvest and ability to cultivate and results in low productivity.

There are few alternatives to farming. Many Hondurans work at temporary factories throughout the year, but this is a relatively unreliable source of income as it offers inconsistent employment. Fishing is also considered an alternative. However, per Larry Overholt, missionary of over 25 years in Honduras, fishing in rivers and streams is producing an increasingly low yield due to the exhaustion of this natural resource. Aquaponics is one solution to produce viable and affordable local food sources throughout the year and can combat the problem of low agricultural productivity due to environmental vulnerability. A prototype system was installed in the spring of 2013 in Siete de Mayo, Honduras.

What is Aquaponics?

Aquaponics is a technique for sustainable food production. It utilizes the synergistic combination of aquaculture (fish farming) with hydroponics (growing vegetables without soil). The two elements of the system are a fish tank and a grow bed with plumbing between them to circulate the water. Fish excrete waste products that render the water unfit, and plants require continued fertilization to grow. By pumping the tank water into the grow bed and letting it drain back into the fish tank, the fish effluent is transformed from ammonia that is toxic to the fish into nitrates that are safe for fish and essential for the plants as fertilizer. Moreover, the closed system reduces dependency on many other variables such as water, land, and fertilizers and provides a reliable dietary supplement of organically grown fish and vegetables.

The Market Solution

The production and distribution of aquaponics systems in Honduras is proposed to address the issues of agricultural productivity, a vulnerable environment, food insecurity and nutritional deficiency. How aquaponics systems are able to solve these 3 main issues are detailed below.

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[1] http://www.economist.com/node/10566634.

[2] http://www.wfp.org/countries/honduras/overview

[3] http://data.worldbank.org/country/honduras

Agricultural Productivity

Aquaponics systems are self-sustaining and therefore are not dependent on the Honduran dry and rainy seasons like traditional agricultural methods. Its productivity is able to remain consistent year-round with the addition of small amounts of water weekly to address evaporation. Moreover, the abundance of consistent sunlight as well as the warm climate makes areas around the equator prime locations for utilizing aquaponics. Agricultural productivity is also higher in the grow bed of an aquaponics system than in traditional soil because of the constant bathing of the plant roots in a nutrient-rich solution.

Aquaponics offers the following environmental benefits as well:

- Reduces strain on depleted fisheries by providing an alternate source for fish production. As a result, the overall health of the fish in all areas will increase
- Reduces agricultural runoff and eliminates fertilizers which in turn will reduce indirect fish kills
- Avoids problems caused by open ocean fish-farms such as damages to natural habitats and human health concerns
- Requires a fraction (5-10%) of the water required by regular agriculture and pond culture
- Local production reduces transportation externalities required to ship fish to another location
- Aquaponics occupies much less square footage in comparison to traditional farming

Vulnerable Environment

Aquaponics systems are comprised of a subterranean cement fish tank and a grow bed at ground level. Because cement is a sturdy and long-lasting material, the fish tank is able to remain sound for years. The grow bed has no soil and drains back into the fish tank, so the system is less susceptible to damage from minor flooding. The engineering team has developed many design modifications to increase the reliability and durability of the system infrastructures.

Food Security

Aquaponics provides fresh and local food in areas of:

- Drought conditions with no irrigation
- Limited arable or polluted land
- Poor soil quality
- Overfishing
- Poor road access

Products of the System

Tilapia

Tilapia (including all species and hybrids) is the second most important group of farmed fish after carp and the most widely grown of any farmed fish. It is farmed in at least 85 countries, with most production coming from Asia (China) and Latin America (Ecuador, Costa Rica and Honduras). One of the great advantages of tilapia for aquaculture is that they are omnivores which feed on algae, aquatic plants, small invertebrates, detrital material and bacterial films. The individual species may have preferences between these materials but they are a hardy fish and will utilize any and all of these feeds when they are available which is advantageous for users.

Vegetables

A variety of vegetables can be grown through aquaponics – in fact, nearly every vegetable has been produced in aquaponics systems around the world. One limitation includes those vegetables that have difficulty growing in extreme sunlight. Preliminary experience with the prototype in Siete de Mayo, Honduras, indicates that cucumbers grow especially well. The vegetables grown can be dictated based upon on dietary needs or on current market conditions if the proceeds are to be sold.

Purpose of Project

A pilot aquaponics system was designed and tested in Siete de Mayo, Honduras by an Ohio State Engineering Capstone team in 2012-2013. The great success of the pilot system resulted in an increased demand in the area for more aquaponics systems. Four customers were confirmed during the October in-country visit. With proper funding, the development of systems throughout a large portion of the 100,000 people in the Choluteca area is feasible.

To match the rise in demand, the need arose for a formal business plan in order to lay out methods for procurement, training, and successful implementation of the additional systems within the area. Therefore, the Ohio State School of Engineering collaborated with the Fisher College of Business to form a cross-functional team. The teams combined are charged with creating a sustainable business model for implementation of aquaponics as a humanitarian solution to address the issue of food security in Central America. Our competitive advantage lies with our partners' deeply rooted connections within the local communities and government, an established customer base, and a successfully implemented pilot system.

Mission

The vision of this project is to create a sustainable in-country business which can provide locals who are interested in owning an aquaponics system the means to do so. This business will supply the necessary short and long-term materials for the building of aquaponics systems that will produce nutritious fresh fish and vegetables through the minimal use of resources. Therefore, the ultimate goal is to benefit the end-user and to make aquaponics available to the local and surrounding communities.

Current Status

The redesign of the pilot system has addressed several issues such as solid waste removal, pump clogging, construction materials and techniques, prototype lighting as well as improving cost efficiency and durability. A prototype is being built on Ohio State's Agricultural campus in order to test effectiveness and ensure a smooth transition in May of 2014. Final specifications are not included in this document.

Based on the results of the pilot system, the benefits of the systems are quickly spread by word of mouth throughout the community as they recognize the nutritional and other qualitative benefits. The scalability of the system is limitless. The system itself can be sized up or down and the expansion of the business is only dependent on the growth rate of the initial seed fund. This technology has already been tested in other parts of the world such as Africa.

Business Model

Assumptions and Up-front Capital Requirements

There are both upfront building costs for the system as well as ongoing operating costs that are incurred. Upfront costs include everything that is required to build a fully functional system such as the grow bed and water pump. Ongoing costs include variable purchases such as seed, feed, water, electricity and maintenance. The economies of scale provided by the implementation of this business will deliver value to the end consumer by providing a lower cost per unit as well as regulation, supervision, and access to long-term repayment.

The cost of the base model system can vary based on the user's current resources and/or needs. For example, if the user does not currently have an electricity source, they would need to install that service. Additionally, depending on other livestock in the area, the user may need to install a fence around the grow bed to protect crops. These variations are outlined in Table 1. Costs are the culmination of a bill of materials that was assembled during an in-country visit in October 2013 and reflect accurate pricing assumptions (Not included in document). Moreover, the front-end users insisted they will collect the gravel necessary for the system as well as build the systems themselves. Therefore no cost for gravel or labor is included in the upfront costs.

Other upfront costs that may not be accounted for include site preparation such as creating a flat surface for the system or administrative and registration costs that may be required by law.

Table 1: Upfront Capital Costs*

Upfront Costs (Gravel provided by end user, labor not included)	Description	Cost ($)	Lempira Cost
Basic	Basic System with tank cover.	$ 238.26	HNL 4,889.07
Basic Plus Electric Service	Adds electrical service and outlet	$ 374.99	HNL 7,694.90
Basic Plus Electric Service and Fence	Adds grow bed fence	$ 485.30	HNL 9,958.30
Full System	Adds liner (material cost only) and gravel (no labor or no delivery)	$ 586.23	HNL 12,029.38

*Costs based on prototype design and in-country costs as of October 2013, subject to change pending 2014 prototype installation

System Output

The system's output can be valued at their respective local market values. This valuation helps provide a realistic benefit analysis of the system over time. The output efficiency of the system is dependent on many factors such as the weather and current life cycle of fish and vegetables. For example, less intense sunlight results in a lower growth rate of plants and therefore a smaller harvest. Likewise, based on the age of tilapia in the tank, there may be an inconsistent amount yield from month to month. Actual results from the pilot system yielded 4 pounds of fish per week after just 2 months after installation. The vegetable garden showed a rapid growth rate compared to traditional methods but the variety of produce made it difficult to measure. Carlos, the owner of the system, grew on average 15 pounds of assorted vegetables per month including beans and cucumbers (See Table 2).

The initial input of tilapia fingerlings will be 200. The fingerlings will grow to full maturity within a timeframe of 2-8 months. Once they reach maturity, the user will begin to consume the fish at the rate of 4 lbs. per week. Next, the user will make adequate steps to keep the tank full of about 200 fingerlings. Finally, from steps taken to clean the fish, only a percentage of the total body weight of the fish is available for consumption by the end user. Typically this will be about 44% of the total body weight.

Moreover, the grow year for vegetables is now 365 days. This differs from the status quo of season growing (approximately 210 days). We assume a maturity rate that is based off the known growth time of a cucumber which is 55 days but can easily be adjusted to take into account other fast growing items such as beans.

Table 2: Estimated Output of System

Item	Market Value	Mature Rate (months)	Harvest Frequency (per year)	Lbs/ Harvest	Yield % for Consumption
Tilapia	$1.50	4.0	52	4	44% (of fish is edible)
Vegetables	$1.50	(55 days/30 days per mo.) = 1.83	12	15	100%

System Ongoing Inputs

In order to value the ongoing costs of the project, many assumptions regarding the market price, quantity, and quality of inputs must be made. Moreover, depending on seasonality, consumption by the user, and overall diversity of crop production, the need for inputs may vary from user to user. To best value the price of inputs such as fingerlings and vegetable seeds, we researched current market prices as well as received input from locals.

On average, the user will restock the number of fingerlings as the total number of mature fish decrease by half. This is more cost efficient that smaller orders because by economies of scale, the user can purchase at a cheaper price per fingerling. Next, the user will take steps to preserve seeds from the existing plant in the grow bed. However, if the user grows a variety of products based on seasonality or individual preference, the cost includes the purchase of seeds about every 55-70 days.

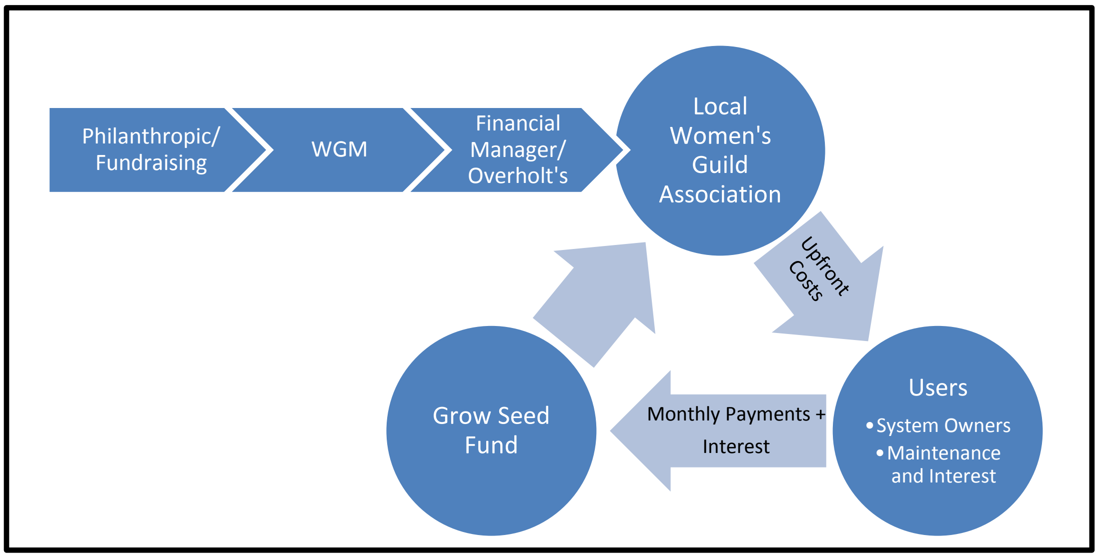
Another necessary cost is fish feed. This is a necessary purchase because the fish need adequate animal protein to grow healthily. However, this cost can be partially offset by combing vegetation sources from the grow bed with the fish feed. Therefore we estimate only an annual large shipment of feed is necessary. This assumption will change based on the scale of the unit, number of mature tilapia, and other food resources available. Finally, the system uses 35 Kwh of electricity per month. While electricity is be free, by government subsidy, for users up to 100 Kwh per month, the user may be using the electrical source for other uses and any additional electricity costs need to be incorporated into this analysis.

Yearly costs average $52.00 yearly with the assumption of free electricity and following average restocking timing. The annual costs are then averaged over a 12 month period to reach a monthly rate. This monthly rate of $4.33 may change based on seasonality and personal user decisions.

Sourcing and Value Creation

Since the local consumers cannot afford to purchase all upfront supplies at one time, funds for the initial implementation of the systems will be sourced from an initial 'seed fund' controlled by in-country partners in coordination with the World Gospel Mission (WGM). Funds will be placed into a women's guild association in the community to receive the first aquaponics installations. As the women of rural Honduras are typically responsible for child care within the family, as well as the provision of food, allowing them to control funds has proven to be very effective.[4]

Figure 1: Flow of Funds



Procurement and distribution of supplies will be controlled by in-country managers who will request funds from the seed fund. These managers are workers of Larry and Angie and are also very familiar with the local community as well as the functioning of the aquaponics systems. Their function will allow bulk purchases of upfront building materials resulting in lower per unit costs. Supplies will be procured from a combination of local vendors and the lowest priced regional vendor. In order to maintain customer satisfaction with the systems, the local in-country managers will also perform regular maintenance and up-keeping checks on installed systems. Overall, the end user will benefit from the lower per unit cost of materials as well as enjoy a low repayment financing option.

Each customer's unit will be funded by a loan in which the user will pay flexible monthly amounts toward the principle and interest. The payback period will be 24 months with monthly payments. This was chosen through the focus group results as their preferred payback timing.

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[4] http://www.sustainableharvest.org/news-articles/articles/newsletter-articles/micro-finance-in-honduras-improving-womens-lives

In order to cover overhead costs of operation, the labor of the managers, as well as grow the fund, an interest rate will be charged in addition to the principal repayment of the loan. Some expenses include the gas, labor, and vehicle expenses of maintenance workers as well as profit to motivate their work. With the initial five to six units being installed, it is estimated that the payment to the manager will be around 40 USD per month, or $7 per unit. This wage, along with the number of managers, may increase as more systems are installed.

While most loans in Honduras vary between 20-30% interest rates, structuring payments will be made on a case by case basis. As money is borrowed by community members and then repaid to a shared fund, interest income is retained within the community. The personal accountability in the community keeps default rates close to 0%[5]. The estimated monthly payment including interest for growth and maintenance, assuming the user pays 12 months out of the year, would be 25 - 30 USD, or roughly 18-20% of the monthly GDI per capita of Honduras for the 24 month payback period.

Return on Investment

The system is designed to serve as an addition to their current food source, not necessarily as a revenue generating product. However, if a harvest results in a surplus, the excess products may be sold in a local market. While this is not the purpose of the project, the end-user may benefit from creating an efficient and effective system that serves beyond basic nutritional needs.

Understanding the possible changes in yield due to environmental factors as well as using the assumption of average market values for inputs and outputs, a user can expect to average about $34 a month in benefits from system output (See Table 3). This would be a consistent output value about 2-6 months after installation to allow initial fingerlings to grow to maturity.

Table 3: System Output Market Values

Item	Annual Yield (lbs)	Annual Value	Annual Lempira	Average Monthly Value	Lempira Monthly Value
Tilapia	91.5	$ 137.28	HNL 2,816.99	$ 11.44	HNL 234.75
Veggies	180.0	$ 270.00	HNL 5,540.40	$ 22.50	HNL 461.70
			Total Monthly Value	$ 33.94	HNL 696.45

[5] http://www.sustainableharvest.org/news-articles/articles/newsletter-articles/micro-finance-in-honduras-improving-womens-lives

Table 4: User's Monthly ROI (During Payback Period)

Payback Period (Months)	24
Total Upfront Cost of Base Model (w/o Electricity)	**$238.26**
Monthly Payment = (Base Unit/24)	$10.00
+ Monthly Labor Cost = $40 / (5 or 6 Units)	$7.00
Base Cost	**$17.00**
+ Profit Surplus	$3.00
+ Interest Payment	$5.00
+Ongoing Input Cost	$4.00
Total Payment	**$29.00**
Total Monthly Market Value	$34.00
Return on Investment	17%

Table 5: User's Monthly ROI (after Payback of 2 years)

Monthly Labor Cost = $40 / (5 or 6 Units)	$7.00
Profit Surplus	$3.00
Ongoing Input Cost	$4.00
Total Payment	**$14.00**
Total Monthly Market Value	$34.00
Return on Investment	142%

Table 6: System Lifetime ROI (10 years)

Expected Life of System (Months)	120
Total Monthly Payments (24 mo x $10)	$240.00
Total Monthly Labor Costs ($7 x 120 months)	$840.00
Profit Surplus ($3 x 120 mo.)	$360.00
Total Interest Payment (continuous rate) ($5*24 mo.)	$120.00
Total Input Ongoing Cost ($4 x 120 mo.)	$480.00
Total Cost	(2,040.00)
Total Market Value ($34 x 120)	$4,080
Return on Investment	100%

At this rate, the seed fund would grow by $120 per unit per every two year payback period. If six units were installed, that would be $720 added to the fund after two years in addition to the full payment of each of the $238 systems returned ($238*6 + $720 = $2,148). This would double the original seed fund amount of $6,000 roughly every 3 years. In addition, the manager's would bring in $60 a month for overseeing six units with the potential to make an incremental $10 per additional installation. In order to meet the average Honduran income of roughly $2,000, a manager would have to oversee only 20 units per year. This business will be sustainable and profitable for both the worker and end-user.

The Market

Target customer

The initial customers are local community members in the village of Siete de Mayo, Honduras but focus will extend to other areas throughout Choluteca, Honduras with the vision to serve the rest of Central America. Siete de Mayo was the location of the initial pilot unit and the community has experience with how the system functions and the necessary costs and maintenance required on a daily basis. The system will solve the customer's problem of an inconsistent food supply due to seasonality as well as address the challenge of food security and nutrition. The market for this product is essentially limitless with the correct loan infrastructure to back its expansion. Current customer's reactions to the system's benefits indicate a healthy market for the business to spread quickly and effectively.

Competition

There is relatively low competition for aquaponics in Honduras. One potential source would be Granjas Marinas, an aquaculture company in close proximity to the start-up location. However, Granjas Marinas is a profit-driven company of Honduras that primarily sells overseas. Our aquaponics business is striving to serve poor rural residents who do not generally have access to Granjas Marinas' products. It can be inferred that Granjas Marinas will likely not attempt to enter our target market because that is not within their business model. There are relatively low barriers to entry in this business, because of low capital intensity. Again, our competitive advantage lies with our deeply rooted connections within the local communities and government, an established customer base, and a successfully implemented pilot system.

Funding Request

We are seeking $6000 for the installation of 4-6 more aquaponics systems in May 2013, a seed fund for micro-financing and business start-up costs. As described above, this will extend to cover labor costs as well as initial installation and procurement expenses. Finally, we expect additional installations to be made by the end of 2014 in which the seed fund would also need to cover. Additional funding would contribute to seed fund growth in other areas as well as team travel expenses in May 2014.

Social Impact Summary

Beyond nutritional impact, the system installations and everyday functioning serve as an educational tool both for the individual as well as the community. An understanding of the components and dynamics of the system also helps users comprehend important agricultural, scientific and social concepts. Moreover, the loan structure provides educational lessons about fiscal responsibility and accountability. Repayment will enable a community or "seed" fund to grow and allow others in the community to install their own system.

Ownership of the system also raises the personal wealth of one's assets and their individual satisfaction as the end user has something to "show-off" to the community and to visitors. Finally, the system business provides useful job skills in construction, maintenance, and agriculture as well as and training opportunities which can lead to employment opportunities within a community.

Overall, this multidisciplinary project has broad implications socially, environmentally and economically for the citizens of Siete de Mayo and potential areas around the world. It is a relatively simple but sustainable solution to alleviate food scarcity as well as assist those who are in need with a powerful tool to improve their daily lives.