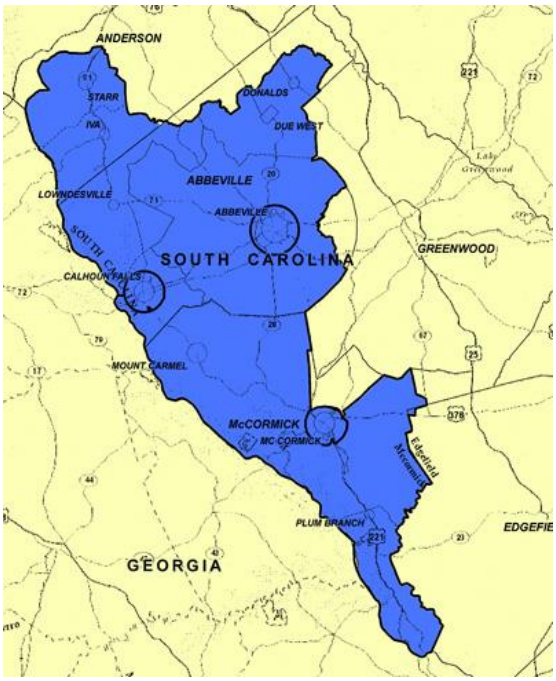

Freshwater Coast Large Scale Aquaponics Greenhouse

Feasibility Study

Freshwater Coast Community Foundation

July 2016

The Freshwater Coast Aquaponics Feasibility Study is a project of the Freshwater Coast Community Foundation, in South Carolina, and Clemson University Cooperative Extension Service.

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I. INTRODUCTION

A. PURPOSE

The purpose of this study is to determine the economic feasibility of a greenhouse aquaponics operation in the study area.

Aquaponics is a very sustainable method of growing fish and produce. Aquaponics systems can create a large diversity and quantity of produce per square foot as well as fish. The aquaponics system will be located in the study area inside of a greenhouse. The greenhouse will contain vertical aquaponics towers, which save space by utilizing the height of the greenhouse, rather than spreading the systems out on the floor of the greenhouse. The fish used and grown in the aquaponics systems will be tilapia. The aquaponics towers will take up one side of the greenhouse. The other side of the greenhouse will have raised beds containing soil.

The overall goal of this aquaponics greenhouse is to produce vegetables and tilapia on a large, commercial scale using methods that are much more sustainable and resourceful than traditional growing methods.

B. DEFINITIONS

Aquaponics is one of the most sustainable methods of growing produce known today. Aquaponics combines hydroponics and aquaculture (fish farming) to create an almost self-sustaining ecosystem with a regular cycle of nutrients. Hydroponics can be defined as growing plants in water without any soil. The plants are supported in a container of inert media such as gravel, that are elevated above a deep-water culture system filled with water that also provides oxygen through a pump at the bottom. The roots of the plants are then able to grow downward into the water receiving oxygen and nutrients that are added by the farmer. The production and well being of the plants is completely dependent on a regular supply of nutrients that must be manually added to the water.

The idea of aquaponics combines some of the methods used in hydroponics with aquaculture. Water from the fish tanks is cycled out of the tanks and into the hydroponics system, watering and providing nutrients to the plants. The plants act as a natural filter, cleaning the water before it runs back into the fish tank. In order for this system to work properly, a colony of nitrifying bacteria must be living inside the fish tank and worms must be living inside the inert media. The bacteria convert the ammonia from the fish waste into the nitrates that the plants need to survive. Worms work to eliminate larger solid waste and decaying plant matter into vermicompost. Some aquaponics systems are a deep-water culture style system. In a deep-water culture system, no media is used, but plants float on a raft on top of the water while their roots grow into the water. The fish also need dissolved oxygen regularily pumped into the water. This can be done with air-stones. With oxygen, bacteria, and worms living amongst the fish and plants, a cycle and ecosystem is created. The only inputs that are regularly needed are electricity for the water pump and feed for the fish. Water needs to be added occasionally as it evaporates

and is absorbed by the roots. This operation will also need to be constantly monitored for water temperature and pH levels.

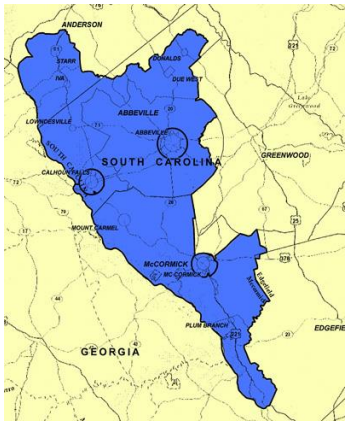
Aquaponics is one of the most sustainable methods of food production known today. One of the reasons is because no water is able to flow away or seep into the ground, the water can only evaporate and be absorbed by the plant roots. The plants receive the nutrients they need from the fish food that is used. Finding a good quality feed with all nutrients that both the fish and plants need is important.

C. THE STUDY AREA

The study area is known as the Freshwater Coast, which is all of McCormick County, Abbeville County, and the Starr-Iva area in Anderson, South Carolina. The Freshwater Coast has many beef and vegetable producers. There are not many fish farms near the area to supply fresh local fish. There are also not many aquaponics producers in the area. There is one producer in Columbia, one producer in Aiken, one producer in Anderson, and one producer in Hartwell.

The U.S. Census Bureau has estimated the population of McCormick County in 2015 to be 9,706. For Abbeville County the estimated population for 2015 was 24,932. The combined population for the Starr-Iva area in 2015 was estimated to be 1,469. The total estimated population of the Freshwater Coast in 2015 was 36,107. The total estimated population of the state of South Carolina in 2015 was estimated to be 4,896,146.

D. DEMOGRAPHICS



The towns in the Freshwater Coast area are rather poor compared to the rest of South Carolina. The median household income for the Freshwater Coast is lower than South Carolina's as a whole. Generally, people with lower income will consume less healthy and fresh food. Obesity rates for both Abbeville and McCormick counties (34%) are fairly high compared to the rest of South Carolina.

Table 1: McCormick, Abbeville, Starr, and Iva

	McCormick County	Abbeville County	Starr	Iva	South Carolina	Source
Median Household Income	$38,919	$35,409	$38,125	$23,906	$45,033	Vintage 2015 Population Estimates
Individuals Below Poverty Level	21.6%	23.1%	6.0%	23.4%	18.3%	2010-2014 American Community Survey
Educational Attainment: Percent High School Graduate or Higher	78.2%	77.7%	85.0%	62.5%	85.0%	2010-2014 American Community Survey
Health Insurance Coverage: Percent Uninsured	10.5%	15.0%	26.2%	17.6%	15.9%	2010-2014 American Community Survey
Median Housing Value	$105,300	$89,000	$90,000	$69,100	$137,600	2010-2014 American Community Survey
Total Housing Units	5,460	12,031	64	563	2,160,383	2010-2014 American Community Survey
Number of Companies	866	1,385	N/A	N/A	360,397	2007 Survey of Business Owners
Male Median Income	N/A	N/A	$23,333	$18,262	$29,710	2010-2014 American Community Survey
Female Median Income	N/A	N/A	$16,875	$12,300	$19,069	2010-2014 American Community Survey
Adult Obesity	34%	34%	N/A	N/A	31%	2016 County Health Rankings

II. MARKET ASSESSMENT

A. TILAPIA IMPORTS AND POPULARITY

Table 2: USDA U.S. Tilapia Imports and Prices

Country	Pounds Imported to U.S. in 2014	Pounds Imported to U.S. in 2015	U.S Dollars Paid in 2014	U.S Dollars Paid in 2015
China	410,615,000	395,677,000	806,510,000	670,670,000
Indonesia	25,592,000	22,990,000	78,325,000	74,413,000
Honduras	22,776,000	21,779,000	81,515,000	72,441,000
Ecuador	5,560,000	6,466,000	15,279,000	18,059,000
Costa Rica	12,027,000	11,273,000	42,295,000	37,988,000
Colombia	9,128,000	11,882,000	33,288,000	44,412,000
Other Countries	22,785,000	26,028,000	57,165,000	63,126,000

Table 3: U.S. Tilapia Popularity Based on Raw National Marine Fisheries Service Data

2010		2011	
Shrimp	4.0	**Shrimp**	4.2
Canned Tuna	2.7	**Canned Tuna**	2.6
Salmon	1.999	**Salmon**	1.952
Tilapia	1.450	**Alaska Pollock**	1.312
Alaska Pollock	1.192	**Tilapia**	1.287

Data in pounds per capita

The majority of the tilapia consumed in the United States comes from China. The United States does not supply much of the tilapia it consumes. It is clear that tilapia is extremely popular and largely consumed in the United States. There is definitely a demand for tilapia in the United States

B. MARKET OUTLETS

Existing market facilities include the Abbeville Farmers Market, Greenwood Farmers Market, three South Carolina Certified roadside market stands in Abbeville, the McCormick Farmers Market, and the Anderson County Farmers Market. Many of these farmers markets are not open all year, most of them are only open from late May to Late October. Other market outlets include restaurants and grocery stores wanting to purchase local fish or produce. Most grocery stores have pre-existing contracts with larger farmers for their fish and produce, and many restaurants do not care about buying local fish and produce, so farmers markets and roadside stands will be ideal to sell the fish and produce from the greenhouse. Most grocery stores and restaurants in the local area are not going to leave their trusted suppliers. Many of these roadside stands are located on high traffic roads in the city or off of highway 72 or 221. Some local producers sell their produce at their farm or right out of their greenhouses.

Most fees for the farmers markets will be between $5-$10 to rent a table for the allotted time. In order to produce tilapia in South Carolina, an aquaculture permit must be purchased. This permit costs $100 for the first year and $20 per year to maintain the permit. This permit must be on hand in order to sell tilapia at farmers markets in South Carolina. Also the vendor must obtain a non-indigenous permit as well as a wholesale/retail permit in order to sell tilapia to the public. Both of these permits are free. All permits can be purchased and obtained through the South Carolina Department of Natural Resources. All permits must be on hand while selling the product at the farmers market. SCDHEC must grant approval of the processing facility in order for the producer to sell directly to the consumer. If the producer wants to sell directly to customers and sell wholesale, the seller must use an approved facility, must register with SCDA, and will be subject to state and federal food safety regulations, which includes completing seafood HACCP training. Fish must be properly iced and stored at 45 degrees Fahrenheit or below. All fry purchases and mature tilapia sales must be reported to SCDNR. Receipts, bill of ladings, and invoices must be kept on hand at all times including at the point of sale. DNR needs to track the sales of tilapia because they are not indigenous to South Carolina.

C. PRODUCT MIX

Aquaponics systems are known for growing large amounts of leafy greens. These plants grow particularly well in aquaponics systems. They take up very little space and mature at a fast rate. This aquaponics system will contain several varieties of lettuce and other leafy greens. The majority of the greenhouse will be green leaf lettuce due to the small space it needs to grow. Although tilapia are a huge part of this operation, not many tilapia will be produced, the main result will be leafy greens. The tilapia that are used will be blue tilapia. Tilapia will grow to be around four pounds in weight when mature. The fish feed that will be used is a combination package from AquaNourish, providing different feeds for different sized tilapia.

III. EVALUATING THE ECONOMIC FEASIBILITY OF THE OPERATION

A. THE PROPOSED GREENHOUSE FACILITY

This study will analyze the feasibility of one greenhouse that will be used for aquaponics. The greenhouse is 30 feet wide and 96 feet long. The greenhouse will have 2,880 square feet of floor space. The greenhouse will also have 6' tall walls and a rounded roof, which will allow for vertical systems that will save ground space. This greenhouse will contain four large fish tanks. Water from each fish tank will flow out of the tanks and into four settling tanks for filtration. That water will then flow out of the filtration tanks and into four living filter media beds. These beds will be made out of two 325gallon IBC tanks that are cut in half. These tanks contain gravel, plants, and worms. All act as a filter for solids that pass through the first filter. Once the water passes through the media beds, it will then flow into the deep-water culture beds. These beds will contain floating rafts holding all of the plants. The water will then flow from each of the grow beds into four sumps. The water will then be pumped from the sump tanks back into the fish tanks. Below is a basic design for this aquaponics greenhouse.

Image 1: Greenhouse Layout

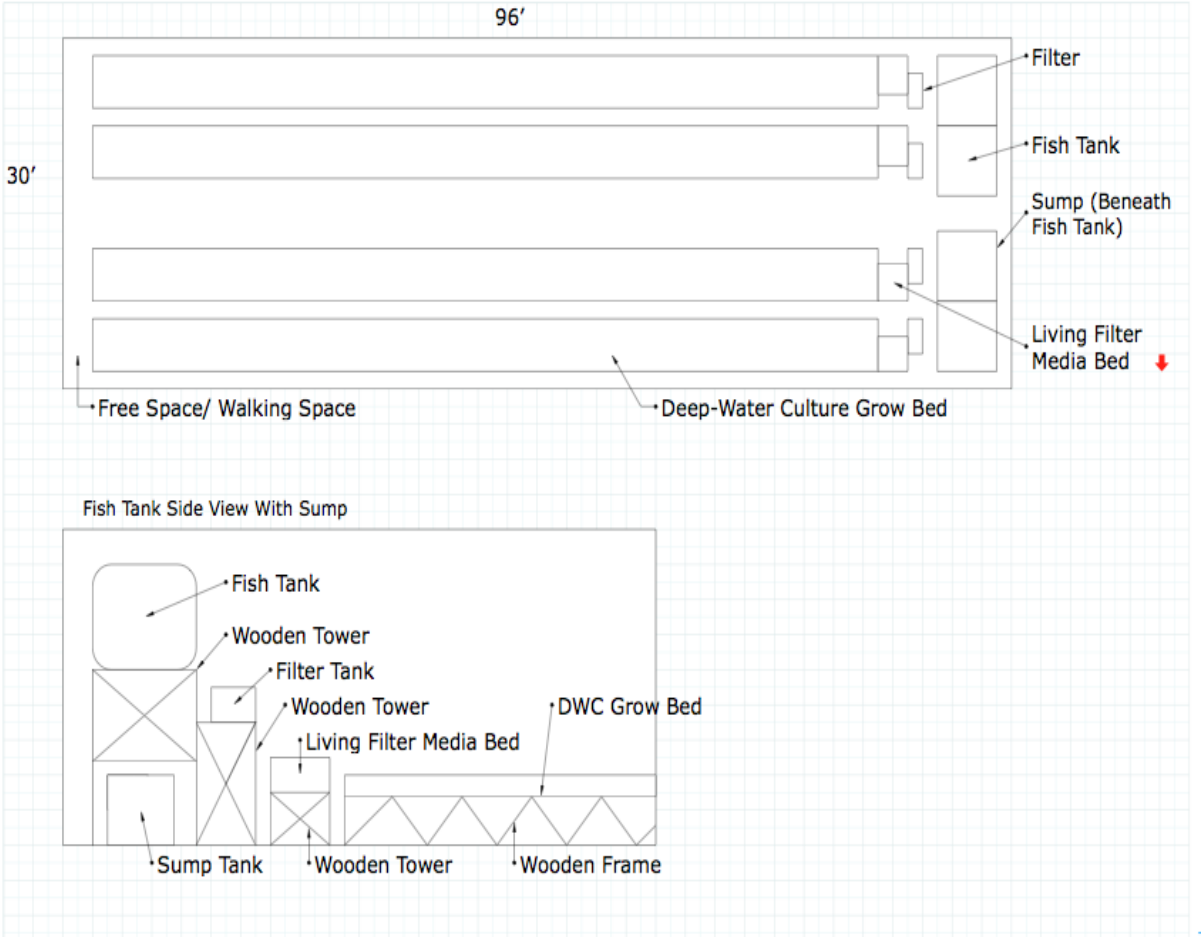


Table 4: Greenhouse Building Costs

Building Units	Cost
Extrusions	$2,593.33
Rigid Cover Handling	$204.00
SEP230s Heater	$1,535.71
Heater Vent	$117.14
Shutter Guard	$3,134.28
Guard Mount	$240.00
5x20 Vent	$2,162.86
Shutter Crafting	$93.33
Fans (Quantity 4)	$630.35
5x20 Cooling System	$1,865.71
6'x6'9" Sliding Door	$528.57
Air Intake, Poly, Inflation Blower	$924.28
Engineering (2 hours)	$200.00
Electricity Outlets	$46.00
Concrete Pad	$11,000.00
Total:	**$31,175.13**

The overall building costs totaled to be $31,175.13. That is the total cost of the frame structure, concrete pad, fans, plastic covering and siding of the greenhouse, and heater, extrusions, cooling system, etc. Table 5 shows the total cost of equipment and supplies for the aquaponics system to function and is expected to be $12,794.84. The cost includes the pumps, the generator, the tanks, barrels, gravel, soil, etc.

B. OPERATING STATEMENT

The overall operating expenses totaled to be $17,088.12. The direct operating expenses are the purchases of fish and the seeds, totaling to $1,433.50 for all seed and fish purchases. The other direct costs include electricity, fish food, and water, and other miscellaneous items with a total of $4,439.90. The direct costs without labor totaled $5,873.40. Table 6 shows a full breakdown of operating costs.

Table 5: Equipment and Supplies Cost

Input	Cost Per Unit	Quantity	Total Cost
200 gal Fish Tanks	$449	4	$1,796
Sump Tanks	$189	4	$756
Filter Tanks	$89	4	$356
IBC Tank	$410	2	$820
Framing Wood	$400	1	$400
Screws	$67	1	$67
Grow Bed Wood	$1,000	1	$1,000
Plastic Liner	$255	4	$1,020
DWC Rafts	$18	40	$720
Propagation Tray	$6	10	$60
PVC Pipes	$345	1	$345
PVC Joints	$67	1	$67
PVC Glue	$13.92	2	$27.84
Water Pump	$130	2	$260
Air Pump	$56	4	$224
Backup Generator	$4,697	1	$4,697
Gravel (Ton)	$50	1	$50
Water Testing Supplies	$65	1	$65
Fish Tank Net Covering	$16	4	$64
Total:	------	------	**$12,794.84**

Table 6: Total Direct Operating Costs

Input	Cost per Unit	Quantity	Total Cost
Water/Heat/Elec.	$2,500	1	$2,500
Fuel/Oil	$500	1	$500
Repairs/Maintenance	$1,000	1	$1,000
Fish Feed	$169.95	2	$339.90
Permits	$100 ($20 after first year)	1	$100
Tilapia Fingerling	$0.30	245	$73.50
Green Leaf Lettuce Seed	$0.04	10,000	$400
Kale Seed	$0.06	4,000	$240
Spinach Seed	$0.06	4,000	$240
Red Leaf Lettuce Seed	$0.06	8,000	$480
Total:			**$5,873.40**

C. LABOR REQUIREMENTS

Aquaponic systems require daily monitoring. Dissolved oxygen levels, temperature, pH, and total ammonia nitrogen need to be monitored daily. pH levels should remain neutral between 6.5 and 7.5. Optimal water temperature conditions for tilapia should be kept between 70 and 85 degrees Fahrenheit. Weekly monitoring includes checking all nitrate, nitrite, phosphorus, potassium, and iron levels, as well as alkalinity and calcium hardness. Other monitoring includes checking plants and plant roots for disease or nutrient deficiencies. Systems should be checked regularly for leaks or damage. An estimated 20 hours of work a week will be needed to operate this greenhouse. Salary expense is estimated to be $11,214.72. This number will vary.

D. PRODUCT RETURNS

Table 7 shows the projected prices, quantity produced and total revenue per crop along with the fish sales. The wholesale prices were found via the USDA and the South Carolina State Farmers' Market in Columbia. Total revenue (yearly) is estimated to be $34,400.00 for five enterprises. Revenues are just estimates, considering that the prices will changes throughout the year.

Table 7: Total Revenue

Product	Estimated Unit Price per Pound	Total Pounds	Total Revenue
Tilapia	$3.60	100	$360
Green Leaf Lettuce	$1.70	8,000	$13,600
Kale	$2.00	4,000	$8,000
Spinach	$2.00	1,000	$2,000
Red Leaf Lettuce	$1.80	5,800	$10,440
Total:	------	------	**$34,400.00**

Table 8 shows the profits for each crop. As the tables show, all of the crops are above the breakeven point. The total net profit added together for all crops is $9,856.76. Profitability per crop will change significantly depending crop yield, crop failure, and selling price. Table 10 displays the entire feasibility of this study (enterprise budget) including fixed costs such as business and administrative expenses, depreciation, interest on initial inventory, working capital, equipment and building. Total operating cost is estimated to be $17,088.12, total fixed cost to be about $7,455.12, and total expenses at $24,543.24.

Table 8: Profitability of Each Crop

Crop	Total Revenue	Total Cost	Total Profit	Unit Profit (per LB)
Tilapia	$360	$315.35	$44.65	$0.45
Green Leaf Lettuce	$13,600	$9,536.41	$4,063.59	$0.51
Kale	$8,000	$5,614.36	$2,385.64	$0.60
Spinach	$2,000	$1583.59	$416.41	$0.42
Red Leaf Lettuce	$10,440	$7,493.54	$2,946.46	$0.51
Totals:	**$34,400**	**$24,543.24**	**$9,856.76**	

E. CAPITAL REQUIREMENTS

The table below shows the capital requirements needed for particular parts of the operation including total investment, revenues, total cost, total profit, profit margins, payback time, residual income, and ROI. The row categories are: a) land plus overhead, plus three months of operating expenses; b) land plus overhead only; c) all expenses but operating expenses; d) all expenses plus three months operating; e) all expenses plus six months operating; and f) all expenses plus twelve months operating. The total working capital for 6 months is $8,544.06. This number comes from taking the first row total investment minus the second row total investment number. For LOO+6 mo. of Operating Expenses, the return is $9,856.76, profit margin of 28.65% and Payback period of 1 year. For ALL investment, except for Operating Expenses, the return is $11,628.05, profit margin of 33.8% and Payback period of almost 4 years.

Table 9: Capital Requirement with Levels of Investments and Financial Returns

LEVEL OF INVESTMENT	TOTAL INVEST	REVENUES	TOTAL COST	TOTAL PROFIT	PROFIT MARGIN	PAYBACK	RESIDUAL INCOME	ROI
LOO +6 mo. OP. EXPENSES	$10,319.06	$34,400.00	$24,543.24	$9,856.76	28.65%	**1.0 years**	$9,340.80	**95.52%**
LAND +OVHD., ONLY (LOO)	$1,775.00	$34,400.00	$24,970.45	$9,429.55	27.41%	**0.2 years**	$9,340.80	**531.24%**
ALL BUT OP. EXPENSES	$45,744.97	$34,400.00	$22,771.95	$11,628.05	33.80%	**3.9 years**	$9,340.80	**25.42%**
ALL +3 mo. OP. EXPENSES	$50,017.00	$34,400.00	$22,558.35	$11,841.65	34.42%	**4.2 years**	$9,340.80	**23.68%**
ALL +6 mo. OP. EXPENSES	$54,289.03	$34,400.00	$22,344.74	$12,055.26	35.04%	**4.5 years**	$9,340.80	**22.21%**
ALL +12 mo. OP. EXPENSES	$62,833.09	$34,400.00	$21,917.54	$12,482.46	36.29%	**5.0 years**	$9,340.80	**19.87%**

Table 10: Enterprise Budget

ITEM		UNIT		PRICE / UNIT	QUANTITY	TOTAL
CASH RECEIPTS						
Tilapia		LBS		$3.60	100	$360.00
Green Leaf Lettuce		LBS		$1.70	8000	$13,600.00
Kale		LBS		$2.00	4000	$8,000.00
Spinach		LBS		$2.00	1000	$2,000.00
Red Leaf Lettuce		LBS		$1.80	5800	$10,440.00
			Average Price	1.82		
		TOTAL REVENUE :	**per SQ FT**	**$6,880.00**	**18900**	**$34,400.00**
OPERATING EXPENSES		SQ FT				
DIRECT OPERATING COSTS>>>				**$286.70**		**$1,433.50**
Tilapia		SQ FT		$14.70		$73.50
Green Leaf Lettuce		SQ FT		$80.00		$400.00
Kale		SQ FT		$48.00		$240.00
Spinach		SQ FT		$48.00		$240.00
Red Leaf Lettuce		SQ FT		$96.00		$480.00
OTHER DIRECT COSTS>>>				**$3,130.92**		**$15,654.62**
LABOR		SQ FT		$2,242.94		$11,214.72
Fish Feed		SQ FT		$67.98		$339.90
Permits		SQ FT		$20.00		$100.00
Water/heat/elec		SQ FT		$500.00		$2,500.00
Fuel/oil		SQ FT		$100.00		$500.00
Repairs maintenance		SQ FT		$200.00		$1,000.00
PACKING, STORAGE & MKT COSTS>>>				**$0.00**		**$0.00**
		TOTAL OP. EXPENSES :		**$3,417.62**		**$17,088.12**
INTEREST RATE :	5.0%	**OPERATING PROI**	**per SQ FT**	**$3,462.38**		**$17,311.88**
CAPITAL COSTS >>				**$525.14**		**$2,625.70**
INTEREST ON INITIAL INVENTORY	**6.0 Months**	SQ FT		$7.17		$35.84
INTEREST ON WORKING CAPITAL	**6.0 Months**	SQ FT		$78.27		$391.37
INTEREST ON EQUIPMENT / FURNITURE / ...		SQ FT		$127.95		$639.74
INTEREST ON BUILDINGS AND ASSETS		SQ FT		$311.75		$1,558.76
OVERHEAD & OWNERSHIP COSTS >>				**$965.88**		**$4,829.42**
BUSINESS EXPENSES		SQ FT		$175.00		$875.00
ADIMINISTRATIVE EXPENSES		SQ FT		$0.00		$0.00
PERSONAL EXPENSES		SQ FT		$180.00		$900.00
LABOR: MANAGAMENT & ADMINISTRATIVE		SQ FT		$0.00		$0.00
DEPRECIATION: MACHINERY & EQUIPMENT		SQ FT		$207.69		$1,038.43
DEPRECIATION: BUILDING & OTHERS		SQ FT		$403.20		$2,015.99
		TOTAL FIXED EXPENSES :		**$1,491.02**		**$7,455.12**
		TOTAL EXPENSES :		**$4,908.65**		**$24,543.24**
		NET PROFIT :	**per SQ FT**	**$1,971.35**		**$9,856.76**

IV. ECONOMIC IMPACT TO THE REGION

A large-scale aquaponics operation will have a positive impact on the study area. Produce that was locally and sustainably grown will be available to the public. This aquaponics operation would provide locals with fresh sustainably grown food. A large-scale aquaponics operation like this one could inspire locals to start their own smaller scale or family operations. This operation will positively impact the local food supply and availability as well as inspire individuals to grow produce using more sustainable methods.

V. SUMMARY

Aquaponics operations are popping up all over the United States and are becoming and increasingly popular method of growing produce. With water becoming increasingly scarce these days, aquaponics offers very sustainable methods of growing produce, saving huge amounts of water.

An aquaponics operation in the study area would increase the supply of fresh local foods. Also since these plants are grown in a greenhouse, the growing seasons will be extended and fresh produce will be available for longer periods during the year. This operation could also inspire other local growers or hobby growers to adopt the aquaponics method of growing.

This size aquaponics operation would be a good step towards a commercial level aquaponics operation. It is large enough that it can turn a profit, but it is also small enough to be operated by just a few people. This operation would be perfect for an individual who is experienced in aquaponics and is wanting to eventually produce on a commercial level.

Using all of the assumptions in this study, an operation of this size can be feasible to turn a profit if greenhouse space is used wisely and if the operation is run efficiently. The local community also has a large influence in the sale of the produce grown. The prices shown above all can change as seasons change and as time goes on.

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VII. ENDNOTES

Freshwater Coast Large Scale Aquaponics Study

The study was funded by the Freshwater Coast Community Foundation Entrepreneurial Education Grant Program that was awarded to Clemson University Cooperative Extension Service.

On behalf of the Project Team, we would like to thank all of the people who collaborated to this project with their expertise and support.

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