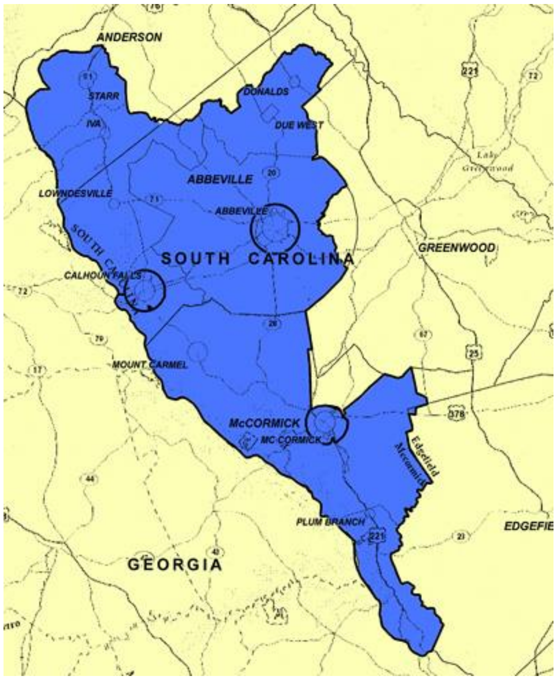

<u>Freshwater Coast Small Scale Aquaponics Greenhouse</u>

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 quantity of produce per square foot as well as fish. The aquaponics system will be located in the study area, inside of a 20 foot by 52 foot greenhouse. The aquaponics setup will be one unitary system of multiple fish tanks and grow beds that will be run by a single water pump. The fish used and grown in the aquaponics systems will be blue tilapia. The aquaponics towers will take up one side of the greenhouse. The other side of the greenhouse will be dedicated to growing plants in soil.

The overall goal of this aquaponics greenhouse is to produce vegetables and tilapia on a small, non-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 media growing beds. 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. Solid waste filters or settling tanks need to be used along with worms. The fish also need dissolved oxygen regularly 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.

Aquaponics is one of the most sustainable methods of food production known today. Some aquaponic systems use more than 90% less water than soil based production due to the fact that evaporation and absorption through plant roots are the only ways that water can leave the system. No water is able to flow away or seep into the ground. 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 of 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

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 that 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 tilapia is not indigenous to South Carolina.

C. Product Mix

Aquaponics systems are known for growing large amounts of leafy greens in a small amount of time. These plants grow particularly well in aquaponics systems. They take up very little space and mature at a fast rate. A few different peppers and onions will be grown in the greenhouse as well due to the small amount of space they take up. This greenhouse will house plants that do not take up much space and mature quickly. The tilapia that is used will be blue tilapia. Tilapia will grow to be around four pounds in weight when mature.

III. EVALUATING THE ECONOMIC FEASIBILITY OF THE OPERATION

A. THE PROPOSED GREENHOUSE FACILITY

This study will analyze the feasibility of one greenhouse that is 20 feet wide and 52 feet long. The greenhouse will have 1,040 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. Roughly half of the greenhouse will be dedicated to aquaponics and the other half will be dedicated to growing in dirt. Lettuce, banana peppers, green onions, and cabbage will all be grown in the aquaponics systems that cover one half of the greenhouse. Kale, spinach, corn and bell peppers will all be grown in the dirt growing area that covers the other half of the greenhouse.

The greenhouse was selected from an online website called the Greenhouse Megastore. The best purchasing options were not in a greenhouse kit but buying individual parts such as the frame and plastic cover separately. This allows for optimal customization to suit the unique needs of the producer. The frame of the greenhouse will need to be anchored into the ground using concrete so it does not blow away in strong winds. The greenhouse will need to be heated by a wood burner that is capable of heating 1,040 square feet. This will cut out huge electricity costs during the cold season. During the warm season the plastic cover on the sides of the greenhouse can be rolled up to allow air to circulate and cool the greenhouse. A 100Watt solar charger controller will be used to charge deep cycle batteries that will power an air pump that will deliver oxygen to the fish tanks. The water pump will need electricity from a direct source. This pump will allow the water to circulate throughout the entire aquaponics system.

With 1,040 square feet available, roughly half of the greenhouse will be dedicated to aquaponic growing and the other half will be dedicated to growing in soil. The aquaponics systems will consist of two 325gallon IBC tanks. 13" of the top of each tank will be removed to create a gravel aquaponics bed. The gravel will fill up 12" of the grow bed. The bottom of the IBC tank will be used as a fish tank. Water will flow from the fish tanks into a filtration barrel that will filter out large solids. The water will then flow from the barrel to the gravel grow bed where plants and worms filter the water again. The water will then drain from the gravel bed into four 4'x8' deep-water culture beds that can contain 240 gallons of water. These beds will be constructed out of 2x12 wooden boards and will be lined with plastic liner. Here plants will be floating on rafts while their roots can grow into the water. Water will then be pumped from the deep-water culture beds back into the fish tanks. There will be two of these systems total taking up roughly 500 square feet of the greenhouse. 288 square feet of the 500 square feet will be growing plants and 32 square feet out of the 500 square feet will be fish tanks. All other space will be used for walk space and space for the heater. The other 540 square feet of the greenhouse will be dedicated to growing produce in dirt.

General labor is required to construct this greenhouse. Individuals will be needed to construct the frame, anchor the frame into the ground, properly measure and cut the plastic covering and siding and cover the greenhouse. Individuals will be needed to help move heavy materials into the greenhouse. Below is a basic design for this aquaponics greenhouse.

Image 1: Greenhouse Layout

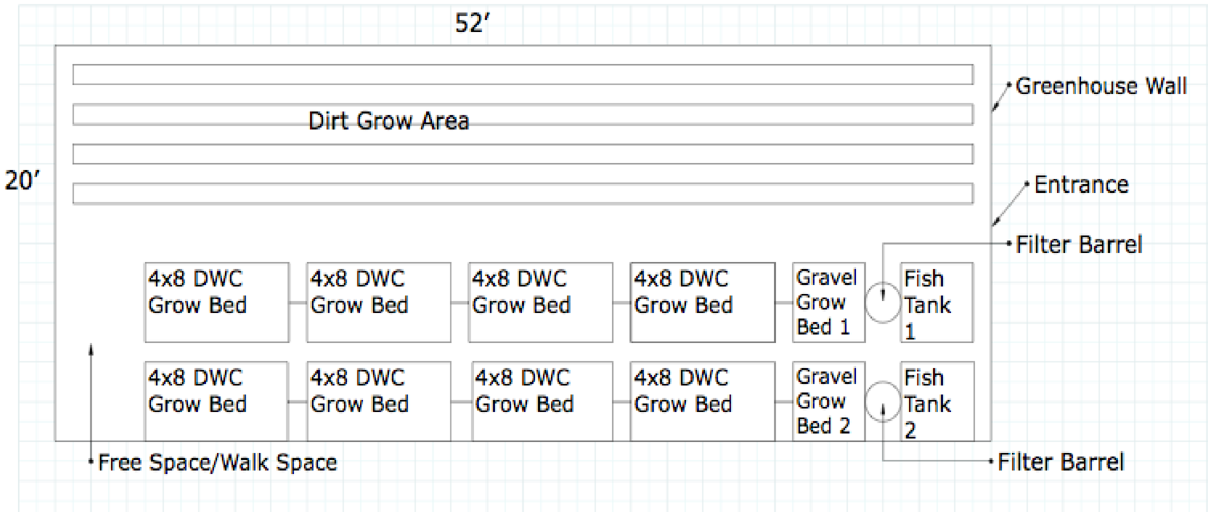

Table 4: Building Costs

Building Part	Cost
Frame	$2,303.00
Plastic Cover	$383.00
Rocket Wood Heating Stove	$539.00
Concrete	$100
TOTAL:	**$3,325.00**

The overall building costs totaled to be $3,325.00. That is the total cost of the frame structure, concrete, plastic covering and siding of the greenhouse, and heating stove. Table 5 shows the total cost of equipment and supplies for the aquaponics system to function and is expected to be $1,457.53. The cost includes the pumps, the tanks, barrels, gravel, soil, etc.

B. OPERATING STATEMENTS

The overall operating expenses totaled to be $1,779.40. The direct operating expenses are the purchases of fish and the seeds, totaling to $281.40 for all seed and fish purchases. The other direct costs include electricity, fish food, and water, and other miscellaneous items with a total of $1,498. Labor is the most expensive cost associated with the production of aquaponics, and we assume the work will be done entirely by the farm operator. Table 6 shows a full breakdown of operating costs.

Table 5: Equipment and Supplies Costs

Input	Cost Per Unit	Quantity	Total Cost
Water Pump	$130	1	$130
Solar Charger	$63	1	$63
Air Pump	$51.39	1	$51.39
Deep Cycle Battery	$75	2	$150
4x4 IBC Tanks	$210	2	$420
Water Barrel	$69	2	$138
PVC Piping	$80	------	$80
PVC Joints	$20	------	$20
PVC Glue	$13.92	1	$13.92
Lumber 2x12	$10.99	24	$263.76
Lumber 2x4	$4.07	8	$32.56
Screws	$8.90	1	$8.90
Plastic Liner	$36	------	$36
Gravel (Ton)	$50	1	$50
Soil	$0	1	$0
TOTAL:	------	------	**$1,457.53**

Table 6: Total Direct Operating Costs

Input	Cost Per Unit	Quantity	Total Cost
Tilapia Fingerling	$0.30	90	$27
Lettuce Seed	$0.04	1,200	$48
Cabbage Seed	$0.04	600	$24
Collard Green Seed	$0.04	600	$24
Kale Seed	$0.06	1000	$60
Corn Seed	$0.06	200	$12
Bell Pepper Seed	$0.08	180	$14.40
Banana Pepper Seed	$0.08	180	$14.40
Green Onion Seed	$0.04	1,440	$57.60
Permits	$100($20 after first year)	1	$100
Water	$500	1	$500
Solar Power	$0	1	$0
Fire Wood	$0	------	$0
Power	$180	------	$180
Big Strike Fish Feed (50lb)	$19	2	$38
TOTALS:	------	------	**$1,099.40**

C. LABOR REQUIREMENTS

Aquaponic systems require daily monitoring. Dissolved oxygen levels, temperature, pH, and total ammonia nitrogen need to be monitored daily. The 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. The plants that are grown in the dirt grow area will also need special care. Water from the aquaponics system can be taken and used to water the plants in the dirt grow area. The plants must also be planted by seed first and transported to the aquaponics system once they sprout. This work is to be done by the farm operator.

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 $5,879.20 for nine 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 Produced	Total Total Revenue
Tilapia	$3.60	40	$144
Lettuce	$1.70	700	$1,190
Cabbage	$1.70	600	$1,020
Collard Greens	$1.50	450	$675
Kale	$2.00	500	$1,000
Corn	$2.00	400	$800
Bell Peppers	$2.60	160	$416
Banana Peppers	$2.50	150	$375
Green Onions	$1.80	144	$259.20
TOTALS:	------	------	**$5,879.20**

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 $2,495.80. 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 $1,779.40, total fixed cost to be about $1,604.00, and total expenses at $3,383.40.

Table 8: Profitability of Each Crop

Crop	Total Revenue	Total Costs	Total Profit	Unit Profit (per LB)
Tilapia	$144	$102.98	$41.02	$1.03
Lettuce	$1,190	$675.87	$514.13	$0.73
Cabbage	$1,020	$562.17	$457.83	$0.76
Collard Greens	$675	$380.14	$294.86	$0.66
Kale	$1,000	$587.62	$412.38	$0.82
Corn	$800	$434.10	$365.90	$0.91
Bell Peppers	$416	$233.89	$182.11	$1.14
Banana Peppers	$375	$212.26	$162.74	$1.08
Green Onions	$259.20	$194.36	$64.84	$0.45
Totals:	**$5,479.20**	**$3,383.39**	**$2,495.80**	

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 $889.70. 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 $2,495.80, profit margin of 42.45% and Payback period of 0.8 years (~10 months). For ALL investment, except for Operating Expenses, the return is $2,609.87, profit margin of 44.39% and Payback period of 2.3 years.

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

LEVEL OF INVESTM	INVESTMENT	REVENUES	TOTAL COST	TOTAL PROFIT	PROFIT MARGIN	PAYBACK	ROI
LOO +6 mo. OP. EXPENSES	$1,964.70	$5,879.20	$3,383.40	$2,495.80	42.45%	**0.8 years**	**127.03%**
LAND +OVHD., ONLY (LOO)	$1,075.00	$5,879.20	$3,427.88	$2,451.32	41.69%	**0.4 years**	**228.03%**
ALL BUT OP. EXPENSES	$5,928.53	$5,879.20	$3,269.33	$2,609.87	44.39%	**2.3 years**	**44.02%**
ALL +3 mo. OP. EXPENSES	$6,373.38	$5,879.20	$3,247.09	$2,632.11	44.77%	**2.4 years**	**41.30%**
ALL +6 mo. OP. EXPENSES	$6,603.21	$5,879.20	$3,224.85	$2,654.35	45.15%	**2.5 years**	**40.20%**
ALL +12 mo. OP. EXPENSES	$7,707.93	$5,879.20	$3,180.36	$2,698.84	45.90%	**2.9 years**	**35.01%**

Table 10: Enterprise Budget

ITEM		UNIT		PRICE / UNIT	QUANTITY	TOTAL
CASH RECEIPTS						
Tilapia		Pound		$3.60	40	$144.00
Lettuce		Pound		$1.70	700	$1,190.00
Cabbage		Pound		$1.70	600	$1,020.00
Collard Greens		Pound		$1.50	450	$675.00
Kale		Pound		$2.00	500	$1,000.00
Corn		Pound		$2.00	400	$800.00
Bell Peppers		Pound		$2.60	160	$416.00
Banana Peppers		Pound		$2.50	150	$375.00
Green Onions		Pound		$1.80	144	$259.20
			Average Price	1.87		
		TOTAL REVENUE :	**per SQ FT**	**$653.24**	**3144**	**$5,879.20**
OPERATING EXPENSES		SQ FT				
DIRECT OPERATING COSTS>>				**$31.27**		**$281.40**
Tilapia		SQ FT		$3.00		$27.00
Lettuce		SQ FT		$5.33		$48.00
Cabbage		SQ FT		$2.67		$24.00
Collard Greens		SQ FT		$2.67		$24.00
Kale		SQ FT		$6.67		$60.00
Corn		SQ FT		$1.33		$12.00
Bell Peppers		SQ FT		$1.60		$14.40
Banana Peppers		SQ FT		$1.60		$14.40
Green Onions		SQ FT		$6.40		$57.60
OTHER DIRECT COSTS>>>				**$79.78**		**$718.00**
Permits		SQ FT		$0.00		$0.00
Solar power		SQ FT		$0.00		$0.00
Electric		SQ FT		$20.00		$180.00
Fire wood		SQ FT		$0.00		$0.00
fish food		SQ FT		$4.22		$38.00
water		SQ FT		$55.56		$500.00
PACKING, STORAGE & MKT COSTS>>>				**$86.67**		**$780.00**
Farmers Market Fee		SQ FT		$28.89		$260.00
Crop Transportation		SQ FT		$57.78		$520.00
		TOTAL OP. EXPENSES :		**$197.71**		**$1,779.40**
INTEREST RATE :	**5.0%**	**OPERATING PROFI**	**per SQ FT**	**$455.53**		**$4,099.80**
CAPITAL COSTS >>>				**$22.56**		**$203.03**
INTEREST ON INITIAL INVENTORY	**6.0 Months**	SQ FT		$0.78		$7.04
INTEREST ON WORKING CAPITAL	**6.0 Months**	SQ FT		$4.16		$37.45
INTEREST ON EQUIPMENT / FURNITURE / ...		SQ FT		$0.00		$0.00
INTEREST ON BUILDINGS AND ASSETS		SQ FT		$17.62		$158.55
OVERHEAD & OWNERSHIP COSTS >>>				**$155.66**		**$1,400.96**
BUSINESS EXPENSES		SQ FT		$75.00		$675.00
ADIMINISTRATIVE EXPENSES		SQ FT		$0.00		$0.00
PERSONAL EXPENSES		SQ FT		$44.44		$400.00
LABOR: MANAGAMENT & ADMINISTRATIVE		SQ FT		$0.00		$0.00
DEPRECIATION: MACHINERY & EQUIPMENT		SQ FT		$12.33		$110.95
DEPRECIATION: BUILDING & OTHERS		SQ FT		$23.89		$215.02
		TOTAL FIXED EXPENSES :		**$178.22**		**$1,604.00**
		TOTAL EXPENSES :		**$375.93**		**$3,383.40**
		NET PROFIT :	**per SQ FT**	**$277.31**		**$2,495.80**

IV. ECONOMIC IMPACT TO THE REGION

A small-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 could inspire locals to grow produce in a more sustainable way and maybe start their own operation. Aquaponics operations could get started and grow to commercial size, positively impacting the region even more. This operation will positively impact 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 perfect for families looking to grow their own fresh food or looking to sell small amounts of produce at local farmers markets.

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 Small Scale Aquaponics Study

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Authors
Bennett Hall, Clemson University
Will Ferreira, FCCF-Clemson Extension Alliance

Collaborations
Stephen Carhart
Lance Beecher, Clemson University