Evaluating the Economic Profitability of Establishing an Aquaculture Research Facility. The case of Clemson University's Aquaculture Center

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Abstract

According to NOAA, imports account for over 90% of the value of seafood consumed in the US. The resulting trade deficit is more than $11 billion, and is expected to increase as demand for seafood products is increasing. Aquaculture can help reduce this deficit, create jobs, and support local economies. However, currently, aquaculture is a relatively small industry in the US. Land Grant institutions can educate consumers and producers, thus helping with the development of the industry. In addition to fulfilling their educational goals, universities may also benefit economically from the development of aquaculture facilities.

The present study utilizes the Net Present Value (NPV) framework with Monte Carlo simulations to evaluate the economic viability of Clemson's Aquaculture Center. The findings indicate that even with a 25% increase in the price of catfish and tilapia, the facility will still be profitable. However, there is a likelihood that the facility will not be profitable, if the initial investment cost exceeds $1,000,000, or the price of tilapia declines to below $2.79.

Keywords: **Aquaculture, Net Present Value, Monte Carlo Simulation, Clemson Aquaculture Facility**

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Introduction

Capture fishery production has reached a plateau since 1980's (FAO, 2016; Di Trapani, 2014; Quass et al., 2015; Little et al., 2016). Moreover, according to FAO (2016), it is not uncommon to have unsustainable levels of fishing. At the same time, the increase in world population coupled with the rise of per capita income in developing countries is expected to create a stronger demand for seafood products (U.S. Department of Commerce, 2009; FAO, 2016). Consequently, the seafood industry faces the challenge of satisfying this increasing demand, without depleting fish stocks, or creating environmental problems.

Aquaculture, defined as "the breeding, rearing, and harvesting of plants and animals in all types of water environments including ponds, rivers, lakes, and the ocean" (NOAA, 2016) has been identified as one of the ways to respond to the aforementioned challenge (Quass et al., 2015; Merino et al., 2012). Although aquaculture is a relatively new industry (Little et al., 2015), it enjoys a substantial growth of the last decades (Little et al., 2015; Asche et al., 2016; Merino et al., 2012). To illustrate, the aquaculture industry has been growing at approximately 8% rate since 1980s (Merino et al., 2012; Little et al., 2016).

However, for aquaculture to remain a viable production option economic considerations (i.e. profitability, economic viability etc.) of the industry should be evaluated. However, to the best of our knowledge, the related literature is scarce. The present study aims to cover this void. Specifically, the objective of the study is to examine the financial performance of Clemson's Aquaculture Center (CUAC). The facility is home to approximately 5 acres of production area with greenhouse and pond production allowing for year round production. Historically tilapia, marine shrimp, and crawfish have been produced at the facility.

Focus Area

The Clemson Aquaculture Facility was founded in 1983, located in the historic Calhoun Bottoms on Clemson University's campus. A full assessment has been completed and plans are proposed to restore the site to working order. The facility is located at the Clemson University Calhoun Outdoor Laboratory and will utilize five acres of surface water that has twenty-one 0.1-0.3 acre ponds, ten 0.25-acre crayfish ponds, six 1/3-acre PAS units, four-1/36 acre PAS units and one-acre 2-acre commercial-scale PAS unit (Figure 1). CUAC was selected as the study area for a number of reasons. First, located on the Clemson University campus the CUAC provides a strategic location for educational utilization and research dissemination. Second, the Upstate of South Carolina has directed efforts to increase awareness for the economic and social development of area food structures that offer a variety of fresh local food for consumption. The vision of sustainable, year-round production of high quality aquaculture products directly promoting the local and state economy and health is already in existence. Third, the surrounding community has proven receptive to "locally grown" foods and has shown a strong loyalty to Clemson University. However, there is a limited supply of fresh locally produced seafood products. Lastly, CUAC will create a unique learning center for Clemson students, youth, and adults interested in learning more about aquaculture, relevant water management, and environmental concerns. Figure 1 illustrates an aerial photo of the facility and figure 2 shows the current state of CUAC.

The services provided by the CUAC will be three-fold; instruction, research, and outreach. The CUAC will be effective in training students in fundamental aquaculture skills which can be used in both aquatic organism production and be an advanced platform for research and evaluation of relevant water management interests. CUAC can be instrumental in applying non-traditional teaching methods to introduce a thought process to bring together students from many disciplines and allow them to apply themselves to work on their strengths and weaknesses. Present aquaculture courses will be taught at CUAC to incorporate field work and labs offering students the opportunity to experience real life conditions and obtain information to use in their future careers. Another growing industry is aquaponics and is becoming very popular for both small and large farms. Information and technology can be demonstrated because this is the future of aquaculture and sustainable agriculture and should be considered an integral portion of the program and CUAC.

The research component of the center will be a showcase for modern operating systems in the aquaculture industry. Students will have the opportunity to work with these systems and labor alongside researchers to improve existing systems or create new more efficient ones. The unique nature of this facility will allow for research that will benefit the industry as a whole and consequently train our students to be more productive when they move into the work force. Considering most of the products CUAC would provide will be for further processing or consumption, this gives the students an opportunity to explore business and marketing techniques used in the industry.

The CUAC will be operated to demonstrate various culture techniques of aquatic organisms and disseminate information through workshops and continuing education programs offered to Clemson University Extension personnel and other individuals interested in aquaculture techniques. Training sessions will cover many topics relevant to the industry. The center will host young people interested in the field of agriculture, such as 4-H and FFA programs, to have access to resources needed to participate in aquaculture and water management projects conducted by their respective programs.

Literature Review

Economic analysis and feasibility studies have been conducted for various aquaculture ventures across the globe. However, a void of literature exists examining aquaculture as a university research facility. Previous research has occurred at both the microeconomic level and the macroeconomic level, analyzing small farms, enterprises, and aquaculture policy (Shang, 1985). Basic microeconomic principles remain constant throughout all forms of aquaculture. Input costs are dictated by feed prices given feed is the largest input into an aquaculture system. Aquaculture embodies shellfish and spine-fish, both of which are pivotal to the world food supply (Shumway et al., 2003).

Recirculation aquaculture can be used to grow a variety of aquatic species. Tilapia are a common species used in recirculating aquaculture systems (RAS). RAS are commonly used in production because of their sustainability. In theory, 90% of water in the system can be recirculated through the system after flowing through a biological filter or a mechanical filter (Rawlinson and Forster, 2001). Aquaculture often has to compete with other economic activities for limited resources. Therefore, production is constantly examined for more efficient uses of these resources to increase revenue of an operation (Shang, 1985).

The University of Florida Cooperative Extension Service (1998) released a publication regarding the economics of small-scale outdoor pond culture for growing tilapia in Florida. Although CUAC's ponds are not used for tilapia production, rather for catfish and crawfish similarities can be drawn between the two. Miscellaneous equipment in the initial investment is comparable to equipment necessary for CUAC. An additional similarities arise in terms of input necessary for successful production of tilapia (i.e. fry, feed, etc.) (Adams and Lazur, 1998).

South Carolina has put an emphasis on local foods in the past decade by creating the Certified South Carolina Grown program. This program is sponsored by the South Carolina Department of Agriculture in an effort to support South Carolina agriculture. Research has shown that consumers in South Carolina are willing to pay a 20-30% premium on locally grown products (Carpio and Massa, 2009). Such premiums allow Clemson University the unique opportunity to excel in providing locally produced food to the community.

Economic feasibility of a production facility can be measured using NPV, Monte Carlo Simulations, and sensitivity analysis (Yeboah et al., 2013).

Model and Methods

The assessment performed on CUAC included economic analysis using a financial indicator of net present value (NPV), then repeating the analysis by applying Monte Carlo simulation under different scenarios. NPV "is the sum of the present values of future net cash flows minus the initial investment" (Olson, 2011). Cost-benefit analysis (CBA) is a financial valuation technique which projects effects of a project in terms of benefits of investment. CBA is often used as an economic tool for decision making in the field of aquaculture (Bhattacharya and Ninan, 2011; Di Trapani et al., 2014; Shamshak, 2011).

The following formula was used for NPV:

$$(1) NPV = -(Initial\ Equity\ Investment) + \sum_{n=1}^{10} \frac{NCF_n}{(1+i)^n} + \frac{Ending\ Net\ Worth}{(1+i)^{10}}$$

where *NCF* denotes the average discounted net cash flows; *t* is the time of cash flow; *n* represents the lifetime of the investment and *i* corresponds to the discount rate (Yeboah et al., 2013). Discounted cash flows from a 10-year period have been computed using a discount rate of 10%.

NPV is pivotal in assessing feasibility of an investment. NPV considers both cash inflows and cash outflows for the entire life of an investment (P.T.A. Ngoc et al., 2016). The higher the value of NPV, the more attractive a project is to investors.

Given the uncertainty of aquaculture systems, the economic analysis has been repeated using Monte Carlo analysis 1000 times. Monte Carlo Simulation, a stochastic model was conducted in Microsoft Excel. Stochastic models allow investments that have fluctuating inputs and outputs to be examined further.

Finally, sensitivity analyses were run to simulate market fluctuations of feed price, tilapia market price, and catfish market price. These were conducted using the Monte Carlo Simulation and were adjusted -30%, -25%, -20%, -10%, +10%, +20%, and +30% against the respective baseline value (Yeboah et al., 2013). Our baseline values include $88,350 for feed expense, $3.99/lb. for tilapia market price, $2.50/lb. for catfish market price, and an initial investment of $634,000. Additionally, the impact of the initial investment was tested at +10%, +20%, +30%, and +60%. We assumed the facility sold 100% of total production.

Data used for all components of the CBA, NPV, and Monte Carlo was collected during the 2014-2015 academic year. Market price for tilapia and catfish were found by conducting a survey of local restaurants to determine willingness to pay for seafood produced on Clemson's campus. Table 1 reports the initial costs for the construction of the center. The start up expenditures included construction of a new greenhouse, aeration equipment, and water pumps. The operating expenditures include feed, fingerlings, and seeds.

The following formula was used for feed calculation:

$$(2) Feed\ Amount = .02(x)\ per\ day$$

where x denotes the fish's body weight.

Results

Tables 2 to 5 report the results of our analysis. The findings indicate that under the baseline scenario the facility will be always profitable, with an average NPV of approximately $400,000 (Table 2). Furthermore, even if the feed cost (one of the most important inputs for the facility) increases by 30%, the results indicate that the facility will remain profitable (Table 2).

In addition to the change in the input cost, we examined the impact of lower tilapia and catfish price on the profitability of the center. The findings indicate that reduction in the market prices will have a higher impact than the increase in cost. To illustrate, a 10% decline in the price of tilapia will reduce the average NPV to approximately $260,000 compared to $400,000 of the baseline scenario (Table 3). Furthermore, a 30% decline in the price will reduce the probability of a positive NPV to less than 1% (Table 3).

The catfish market analyzed in Table 4 provided no threat to the operation with the price per pound dropping 30%. All probabilities of a positive NPV were 100% for the scenarios tested with sensitivity analysis. Finally, the initial investment's impact on NPV was examined. Results from the sensitivity analysis showed increasing the initial investment by 10, 20, and 30 percent respectively had no effect on the probability of NPV being positive. This can be accredited to the amount of catfish produced relative to tilapia production. CUAC's catfish production occurs outside, allowing for only seasonal production. A 60% increase in initial investment dropped the probability of a positive NPV below 100%. However, the 60% increase in capital investments still yields a 93.1% probability of a positive NPV.

Conclusion

Aquaculture offers an innovative yet sustainable approach to food production. Sustainable food production is becoming increasingly important in order to meet the demands of the ever-growing population. Clemson University's on-campus production facility is no exception. CUAC will provide hands-on learning for students throughout not only the College of Agriculture, Forestry and Life Sciences, but students in disciplines all across campus. The facility will utilize land for education, research, and outreach to help fulfil the duties of one of South Carolina's Land-Grant Colleges. The operation will produce tilapia, catfish, crawfish, and lettuce grown in an aquaponics system for members of the community and local restaurants. Economically speaking, the operation is self-sustaining beginning in the first year. Results from several scenarios regarding the risk associated with the aquaculture industry show the operation is a viable investment for Clemson University.

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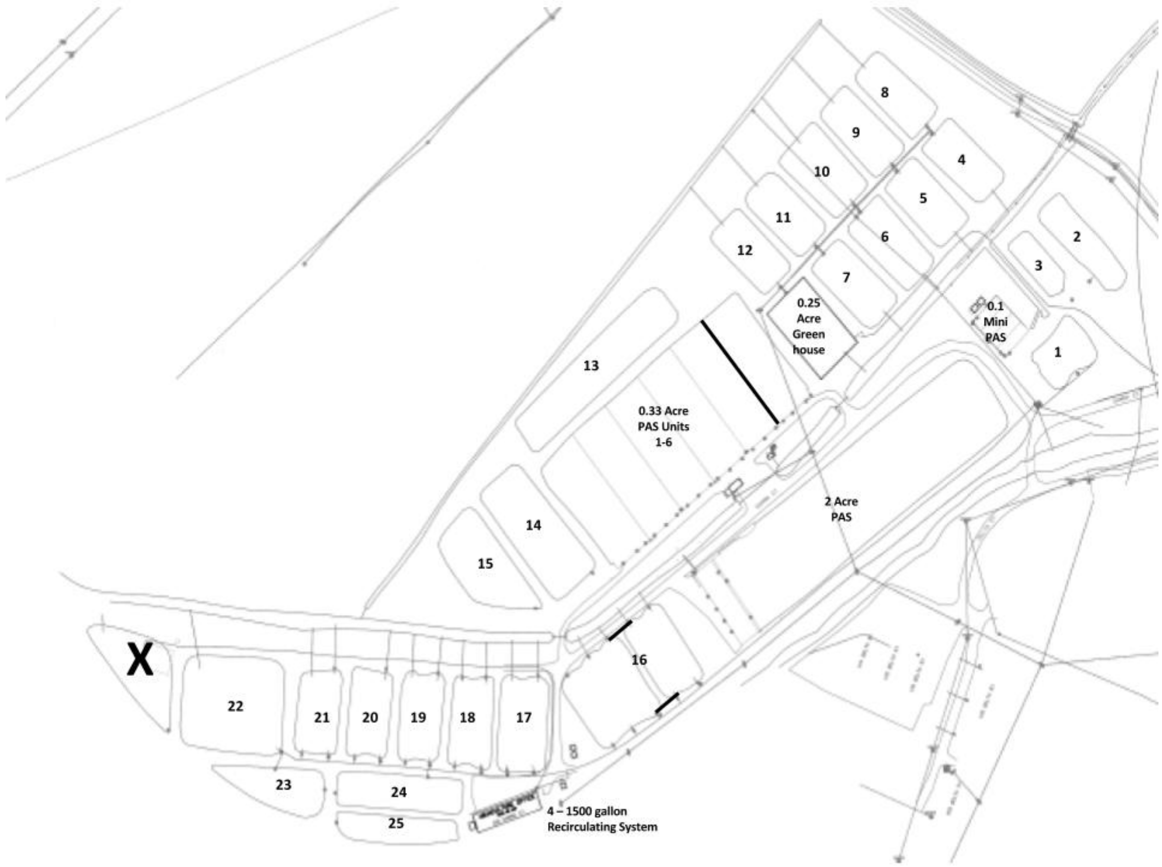

Figure 1. Aerial view of CUAC

Figure 2. Current photograph of CUAC's greenhouse structure.

Table 1: CUAC Expenditure Summary

Clemson University Aquaculture Center	
Total Start-Up Expenditures	$ 256,655.00
Total Capital Expenditures	$ 9,900.00
Total Operating Expenditures	$ 130,300.00
Labor	$ 159,580.36
Security Fence	$ 60,000.00
Cash on Hand	$ 10,000.00
Miscellaneous Equipment	$ 6,326.24
Repairs and Maintenance	$ 1,000.00
Misc.	$ 500.00
Total Expenditures	**$ 634,261.60**

Table 2:
Sensitivity analysis of the Impact of Aquaculture Feed Price on the Probability of Success (NPV>0),

NPV/Scenario	Baseline	10%	20%	30%
Feed Price	**$88,350**	**$97,185**	**$106,020**	**$114,855**
Mean NPV	$ 400,070.58	$ 340,356.84	$ 278,851.03	$ 218,765.44
Min NPV	$ 347,757.92	$ 296,906.83	$ 231,974.33	$ 175,777.45
Max NPV	$ 447,813.73	$ 395,010.75	$ 336,912.14	$ 257,422.87
Pr (NPV>0)	100%	100%	100%	100%

Table 3:
Sensitivity Analysis of the Impact of Market Price of Tilapia on the Probability of Success (NPV>0), Price/lb.

NPV/Scenario	-30%	-25%	-20%	-10%	Baseline
Tilapia Price	**$ 2.79**	**$ 2.99**	**$ 3.19**	**$ 3.59**	**$ 3.99**
Mean NPV	$(22,018.08)	$49,178.36	$ 119,284.13	$ 259,985.33	$ 400,070.58
Min NPV	$(50,296.10)	$6,759.32	$ 84,377.24	$ 216,371.58	$ 347,757.92
Max NPV	$ 7,338.68	$ 82,812.12	$ 156,743.95	$ 304,776.81	$ 447,813.73
Pr (NPV>0)	0.50%	100%	100%	100%	100%

Table 4:
Sensitivity Analysis of the Impact of Market Price of Catfish on the Probability of Success (NPV>0), Price/lb.

NPV/Scenario	-30%	-25%	-20%	-10%	Baseline
Catfish Price	**$ 1.75**	**$ 1.88**	**$ 2.00**	**$ 2.25**	**$ 2.50**
Mean NPV	$127,634.53	$174,302.57	$ 219,456.88	$ 310,023.60	$ 400,070.58
Min NPV	$95,058.82	$129,315.55	$ 187,996.71	$ 261,985.60	$ 347,757.92
Max NPV	$ 159,808.52	$ 219,141.43	$ 257,903.32	$ 358,346.18	$ 447,813.73
Pr (NPV>0)	100.00%	100%	100%	100%	100%

Table 5:
Sensitivity Analysis of the Impact of Initial Investment on the Probability of Success (NPV>0).

NPV/Scenario	Baseline	10%	20%	30%	60%
Initial Investment	**$ 634,000.00**	**$ 697,400.00**	**$ 760,800.00**	**$ 824,200.00**	**$ 1,014,400.00**
Mean NPV	$ 400,070.58	$338,052.82	$ 273,799.95	$210,538.76	$ 20,822.52
Min NPV	$ 347,757.92	$289,668.64	$ 224,179.56	$ 156,288.08	$(23,856.97)
Max NPV	$ 447,813.73	$ 382,634.00	$ 332,326.85	$ 255,735.29	$ 68,801.80
Pr (NPV>0)	100%	100%	100%	100%	93.10%