

ECONOMIC ANALYSIS OF AQUAPONICS PRODUCTION IN INDIANA

1. Introduction

Aquaponics is an intensive fish-vegetable production system that combines aquaculture with the production of plants in a hydroponic system. There are different ways aquaponics can be set up but the basic principle is that fish are raised in tanks, and part or all the wastewater containing excrete nutrients is then circulated to the hydroponic plant production system. The plants take up the water and nutrients, thereby cleaning the water and circulated back into the fish tanks.

Large-scale commercial implementation of aquaponics has been very limited. In the last few years however, there has been increased interest in aquaponics and an increase in the number of aquaponics farms in the US, most of which are small-scale producers. According to USDA 2013 Census of Aquaculture, there were 71 farms practicing aquaponics in the United States in 2013. The value of aquaculture products sold by these farms was less than \$25,000 for 53 farms, between \$25,000 and \$49,999 for 10 farms, between \$50,000 and \$99,999 for 3 farms, between \$100,000 and \$499,999 for 4 farms and between \$500,000 and \$999,999 for 1 farm (USDA, 2013).

In a survey of aquaponics in the United States, Love et al. (2015) found that Tilapia was the fish species that was commonly raised in aquaponics systems while the commonly grown crops were high-value vegetables and herbs such as basil, lettuce, tomatoes, salad greens, kale, chard, bok choy, peppers and cucumbers. The study showed that many aquaponics operations were not profitable. Out of the 257 farms studied, only 31 percent reported profitability of their business within the last 12 months of the study.

Tokunaga et al (2015) investigated the economics of aquaponics production in the state of Hawaii using a case study of three farms. They reported that some constraints to aquaponics operations include high initial investment costs, labor-intensity of the operations, high use of electricity, and sensitivity of profits to output prices. Other risks include plant losses due to plant diseases and pests. Overall, the study found that small-scale farms were profitable, indicating that aquaponics may be a viable option to produce vegetables and fish to local markets. Baker (2010) also analyzed an integrated tilapia and lettuce production system in Hawaii and found it to be technically feasible and profitable. However, the study

reported that there are no additional economic benefits in integrated production compared with only lettuce production. Bailey et al. (1997) also found that aquaponic farms can be profitable in the U.S. Virgin Islands. The authors analyzed data from three sizes of farms producing tilapia and lettuce. Each farm size had positive returns but the smallest farm presented the lowest return and could not be an acceptable investment given the risks associated with aquaponic farming. The lettuce revenue was important to cover the costs of both products. These published results may not be transferrable to farms in the Midwest region because the tropical climate of the study locations might keep some cost factors such as heating low compared to operations in colder climates. Furthermore, prices of many inputs and outputs in these tropical locations could differ considerably from prices in the Midwest so that estimations of costs and revenues may not be comparable between the two locations.

Other studies have also indicated profitability of aquaponics. Chaves et al. (2008) studied incorporating tomatoes grown hydroponically into a recirculation system for channel catfish production in Scotland. They estimated an internal rate of return of 27.32%, but found little difference in financial results compared with producing catfish alone. The authors point out that reduction in effluent in aquaponics would add further benefit in social cost terms. In Australia, Rupasinghe and Kennedy (2010) conducted a study over a 10-year planning horizon for barramundi and lettuce production as stand-alone units, and alternatively as integrated. They observed an increase in benefits equal to the reduction in barramundi effluent disposal costs.

Existing literature on the economics of aquaponics largely covers tropical locations, fish and vegetables species that are mostly applicable to such climates. Therefore, further research is needed especially in colder climates. This paper aims to study the profitability of aquaponics businesses in the US Midwest, a much temperate region than locations studied in the literature.

2. Methodology

Three sources of data were considered to analyze the feasibility of aquaponics production in the US Midwest. First, data from four aquaponics farms of different sizes and investment levels were used. The data include production costs, selling prices, production, infrastructure etc. Tilapia was the main fish species produced at these farms, although some also produce

yellow perch. The second source of information was data from an experiment conducted at a University. The data included production of tilapia with basil, lettuce and tomato. This experiment is a much smaller aquaponics unit. The third source of information is from published research. Data from some of the published papers were used as parameters in this study (e.g., Xie, 2015; Engle, 2015).

The first analysis compares the economics of aquaponics and hydroponics systems conducted in a very similar way. The second analysis constructed three different sizes of aquaponics production; small, medium and large. Each farm size was analyzed as a hypothetical representative farm, with data and parameters of production based on our source of data.

2.1 Comparison of Aquaponics vs Hydroponics

The first analysis compares the economics of two systems - aquaponics and hydroponics. The experiments were conducted in six tanks (fish tanks for aquaponics and water reservoir for hydroponics) of 100 gallons during a 90 day period. The structure used for each experiment had plant beds, water pumps of 115v, tubing, air pumps, air stones, net pots, clay pebbles, germination trays and testing equipment like pH meter, conductivity probe, dissolved oxygen probe and consumables for water test (TAN (Total ammonia nitrogen), NO_3^- , NO_2^- , and phosphate). The aquaponics system used biomedica and media bag and aquatic heaters.

The consumption of energy was the same between both systems using lights (600 kwh, 14 h a day), air pump (47 watts, 24 h a day), water pump (75 watts, 24 h a day) and Greenhouse heating/cooling. Seedlings of lettuce, sweet basil, and 'Washington' cherry tomato were placed at recommended plant density (24, 24, 10 plants per tank, respectively, and an equal number of seedlings were grown in aquaponics and hydroponics. However, the amount of chemicals for pH adjustment was approximately 10 ml every day for aquaponic unit and 5 ml for hydroponics which was directly mixed into the water reservoir. The quantity of water was also different. On the average, 5 gallons/day was used for aquaponics units compared to about half for hydroponics.

For aquaponics production, 70 lb of juvenile fish were farmed. It demanded averagely 70 g per day of fish feed¹. The amount of labor used in the production was equal for both aquaponics and hydroponics. It required two people working two hours for daily management.

Economic analysis was conducted extrapolating operating costs and production of the 90-day experiments for a project of 10 years. Financial indices like Internal Rate of Return (IRR), Net Present Value (NVP), Payback, and Benefit/Cost (BC) were calculated considering a 6% annual discount rate. These indices allow us to analyze the feasibility of each system. First, we compare the economic viability using the same vegetable price. Then, we use different vegetable prices for aquaponics production because some farms report premiums for their aquaponics vegetables.

Hydroponic uses nutrients made of a mixture of commercial fertilizers. Meanwhile in aquaponic system plant nutrients are derived from fish waste. Particularly, ammonia is converted to nitrate by the nitrification process mediated by microbes. Some aquaponics facilities are certified for organic vegetable production, which attracts higher prices that can compensate for the higher cost of aquaponics production. We also calculated the percentage of increase in vegetable prices that makes the two systems equally profitable.

2.2 Analysis of Representative Aquaponics Farms

The three farm sizes examined are small, medium and large. The results of each farm size, as well as cost items and values were derived from the farms surveyed. Each farm has its specific characteristic of production and may not be totally representative, therefore we used information from the literature to supplement the primary data to make each farm size more general. Some cost items used are averages from actual farms, while other costs are data from other sources. Therefore, the data and the information described below were taken in a general way to reach realistic cost. We have no detailed numbers about technical production of vegetables.

All three representative aquaponics farms produce tilapia and basil. Except the small representative farm, which produces peppers in addition to basil. Each scale of production has a specific structure of operational cost and a respective quantity of fish and vegetable

¹ Purina AquaMax® Sport Fish 500

produced. Output prices and investment are not assumed to be fixed, therefore we analyze the results for profits and needed investment according to different combinations of tilapia and basil prices. However, the price of pepper is fixed at \$10/lb. We also consider a production project of ten years with an annual interest rate of 6%.

The data was used on an annual basis for the cash flow, independent of each output harvest. Energy cost was calculated according to prices from Duke Energy in the US Midwest. For labor cost, we assumed wage of \$10/hour and 50 hours/week per worker. Advertising cost is mainly with social media. Although some farmers produce their own fingerlings, we assumed that a producer buys fingerlings. For plant/fish disease management we considered the use of hydrogen peroxide.

3. Results and Discussion

3.1 Aquaponics vs Hydroponics Results

Tables 1 and 2 present the investment for aquaponics and hydroponics, respectively. The initial investment in aquaponics was 8% higher than for hydroponics due to the use of aquatic heaters, biomedial and media bag, and dissolved oxygen probe. The main investment item is installation cost that represents about half of total value in both systems.

The revenue and production costs for aquaponics is shown in Table 3 and for hydroponics in Table 4. Although the production has a 90-day duration, the costs are presented as annual. The cost of aquaponics is 11.6% higher mainly because of consumables for water test and fish feed and fingerlings. In both systems, labor is the more expensive item representing more than 50% of operating costs. All vegetables are produced in 90 days. During this period, lettuce was harvested 3 times, basil was harvested every two to four weeks by removing young shoots, and tomato fruits were harvested after 10 weeks. New seedlings were established for continued production, and transplanted after each harvest. For constant production of fish, new juvenile fish are necessary every year.

Regarding revenues, production of tilapia is ready to be sold every year while lettuce, basil and cherry tomato are harvested at different harvest times. The biomass of tilapia grows 83.5% (114lb) in a year of production. Considering that fish feed was 3.6kg each month, we

have a feed conversion rate (FCR)² of 0.85. FCR is low because besides commercial fish feed, there are plants nutrients in the system that serve as supplemental feed for the fish.

Table 4 presents the results for hydroponics with the same vegetable prices. The lettuce and basil production of hydroponics system is higher than aquaponics production. The reason can be the use of fertilizers instead of solid fish waste. The yield of vegetables in hydroponics is about 11% higher than aquaponics.

Figures 1 and 2 present the share of cost items for aquaponics and hydroponics experiments, respectively. For both cases, labor and energy are the main costs, but for aquaponics, consumables for water test has a significant share as well. The other items represents less than 4% of total operating cost.

The cash flow results are presented in Table 5. Hydroponics and aquaponics showed feasibility in a 10-year production project even using non-organic prices. For hydroponics, all results show very good financial return on investment. A payback of 1.35 shows that the investment can be recovered in a very rapid way. For aquaponics, results from non-organic prices are worse than hydroponics. This is because yield of vegetables are lower and the revenue of fish is small in this system. Besides, costs and investments are higher too.

However, if we consider an increase in prices due to organic production, aquaponics generates better revenues than hydroponics. An increase of 18.40% in vegetables prices makes NPV of both systems equal. The real increase in price due to organic production depends on many variables. Table 5 presents increases from 10 to 30% and the resulting financial effects.

3.2 Results from the Representative Aquaponics Farms

Tables 6, 7, and 8 present the representative total production and operating costs for small, medium and large farms, respectively. For all scales of aquaponic production, labor is the main cost component, but energy, micronutrients, natural gas and fish feed are other important cost components.

The annual fingerlings cost of \$750.00, \$1,500.00, and \$3,000.00 for small, medium and large farms, respectively, accounts for 20% mortality during production. We also consider that each farm sells tilapia at one pound weight and buys fingerlings at \$0.12 per

² The FCR, in the context of aquaculture, is calculated as feed given divided by animal weight gain.

piece. Therefore, the small farm starts production with 6,250 fingerlings to produce 5,000 fishes in a year. Medium farm starts with 12,500 fingerlings to produce 10,000 fishes in a year and the large farm starts with 25,000 fingerlings to produce 20,000 fishes in a year.

In terms of fish feed, for all farm scales, an FCR of 0.6 and a price of \$45 each bag of 50 pounds of tilapia feed were used. This results in an annual cost of \$2,700, \$5,400, and \$10,080 for small, medium and large farms, respectively. Fish are kept in tanks for one year to reach market size.

In terms of quantity of labor required, a small farm needs 23 hours per day, a medium farm, 31.2 hours and a large farm, 65.8 hours, distributed among the employees. All labor costs \$10/hour. We also considered the production of basil 4 times greater than the production of tilapia.

The calculated unit costs of production for each farm are \$4.44, \$3.63, and \$3.60 respectively for small, medium and large farm. For a large farm, the farmer spends \$3.60/lb to produce tilapia and basil. The small farm has greater cost for each unit produced, which suggests economies of scale in aquaponics. The total operating cost is \$127,074.00, \$181,741.26, and \$360,350.00 for a small, medium and large farm, respectively. Considering the total production yield achieved for each type, the feasibility will depend on total investment and prices of tilapia and basil.

To analyze the effect of prices, Table 9 presents the annual profit calculated with varying output prices between \$1.75 through \$2.25 for tilapia and between \$3.00 and \$6.00 for basil. For a small aquaponics farm, if prices of output were \$4.50/lb for basil and \$2.00 for tilapia the annual profit would be \$8,926.00. We also considered the price of pepper at \$10/lb. At prices below these values, almost all results are negative. In this analysis, investment cost, taxes, and interest are not considered. Therefore, positive values do not necessarily mean feasibility of business. The same analysis was done for medium and large farms. The results for large farm are similar to small farm, but obviously with greater values.

To analyze investment for each situation, Table 10 shows similar sensibility analysis. For each price combination, we have the total investment required to get a zero net present value (NPV) considering a 10 years aquaponic project and annual interest rate at 6%. For example, if prices are \$4.50 per pound for basil and \$2.00 for tilapia, a large farm would have zero NPV investing \$374,056 in 10 years paying this investment at 6% annual interest rate.

It means that if the farmer were able to produce the values presented in Table 8 with correspondent operating cost, investing less than \$374,056, the operation would be feasible in 10 years.

To compare the results among the three different scales, Figure 3 presents the change in profit according to basil price variation with tilapia price at \$2.00. It shows that, for all sizes of farm, basil prices lower than \$4.00 will lead to negative results. The different slopes for the lines just mean that the range between the worst result and the best is greater for larger farms.

4. Conclusion

This paper presented an economic analysis of aquaponics production in two different ways. First, we did a comparison between an aquaponics system and a hydroponics system. Second, we constructed three scenarios for representative farms to analyze price and investment sensibility.

In the first analysis, we found that the aquaponics system needs higher investment and operating cost and also has lower production of vegetables compared with the hydroponics system in a 10-year project. Using the same output prices for both systems, the hydroponics system is more economically viable with a NPV of \$80,226 vs. \$29,976 for aquaponics. However, aquaponics production of vegetables can be managed as organic production. Organic products have higher prices in the market and this may make the aquaponics system become more economically viable. If organic vegetables prices are 18.40% greater than non-organic prices, the aquaponics becomes profitable. The feasibility of these prices depends on many factors such as region, quantity produced, seasonality, type of vegetables, etc. In some regions, organic prices are about twice the non-organic prices.

For the second analysis, the production of basil provides better economic results than the fish. All farm sizes are profitable when basil price is \$4.50. If basil price is lower, all scenarios are not profitable. For a profitable investment, the small farmer should aim at receiving as least \$4.50 for basil and \$2.00 for tilapia, otherwise total investment costs will be more than 66% of his annual operating cost. A higher initial investment would require higher prices to have economic feasibility.

The larger farm had the best results, because of lower cost of production. However, our study is only considering the production side. It is also important to analyze the market aspects for each situation. A larger farm should have the market for selling the whole production at higher prices. The vegetable market is very volatile and depends on region, season, demographics, and general supply, etc. This could explain why there are not many large aquaponics farms in US Midwest region.

The results show us that aquaponics is economically feasible under some reasonable assumptions such certified organic production. This activity is also environmentally advantageous since it reduces considerably the use of water and fertilizers.

Table 1 – Total initial investment for aquaponics experiment

Item	Quantity	Unit	Price	Total	Useful life (years)
Fish tanks	6	gallon	\$100	\$600	10
Plants beds	6	gallon	\$100	\$600	10
Water pumps (peristaltic pumps 115v)	3	unit	\$1,000	\$3,000	5
Water pumps accessories	12	unit	\$370	\$4,440	5
Tubing	2	unit	\$160	\$320	10
Air pumps	3	unit	\$300	\$900	5
Air stones	36	unit	\$18	\$648	10
Aquaponic installation cost	2	unit	\$8,500	\$17,000	10
Biomedica and Media bag	2	unit	\$200	\$400	10
Aquatic heaters	6	unit	\$50	\$300	5
PH meter	2	unit	\$450	\$900	10
Conductivity probe	2	unit	\$400	\$800	10
Dissolved oxygen probe	2	unit	\$680	\$1,360	10
Total				\$31,268	

Table 2 – Total initial investment for hydroponics experiment

Item	Quantity	Unit	Price	Total	Useful life (years)
Fish tanks	6	gallon	\$100	\$600	10
Plants beds	6	gallon	\$100	\$600	10
Water pumps (peristaltic pumps 115v)	3	unit	\$1,000	\$3,000	5
Water pumps accessories	12	unit	\$370	\$4,440	5
Tubing	2	unit	\$160	\$320	10
Air pumps	2	unit	\$300	\$600	5
Air stones	18	unit	\$18	\$324	10
Aquaponic installation cost	2	unit	\$8,500	\$17,000	10
PH meter	2	unit	\$450	\$900	10
Conductivity probe	2	unit	\$400	\$800	10
Total				\$33,584	

Table 3 – Operating costs and revenue for aquaponics experiment

Revenue	Unit	Quantity	Price	Total (year)
Lettuce	lb	19,048	\$0.26	\$4,952.41
Basil	lb	8,201	\$1.50	\$12,301.67
Cherry tomato	oz	126,986	\$0.16	\$19,841.63
Tilapia	lb	254	\$2.00	\$507.92
Total				\$37,603.62
Operating Cost				
Consumables for water test	day	1,056	\$5.00	\$5,280.00
Energy - Air pump	kwh	4,873	\$0.08	\$ 413.23
Energy - Water pump	kwh	7,776	\$0.08	\$ 659.40
Energy - Lights	kwh	41,472	\$0.08	\$3,516.83
Energy – Greenhouse heating/cooling	kwh	17,520	\$0.08	\$1,401.60
Seeds - Lettuce	lettuce	24	\$8.00	\$192.00
Seeds - Basil	packet	24	\$4.00	\$96.00
Seeds - Washington cherry tomato	packet	24	\$4.20	\$100.80
Fish feed	kg	43	\$17.64	\$761.92
Fish fingerlings	lbs	140	\$3.00	\$420.00
Clay pebbles	40 L	24	\$28.00	\$672.00
Net pots	50 pots	24	\$23.20	\$556.80
Labor	hours	1,440	\$10.00	\$14,400.00
Chemicals (sulfuric acid)	L	22	\$26.74	\$577.58
Water	gallon	288	\$4.80	\$57.60
Germination trays	unit	12	\$17.95	\$215.40
Total				\$29,321.16
Annual Profit				\$8,282.46

Table 4 – Operating costs for hydroponics experiment

Revenue	Unit	Quantity	Price	Total (year)
Lettuce	lb	28,572	\$0.26	\$7,428.62
Basil	lb	9,259	\$1.50	\$13,888.98
Cherry tomato	oz	126,986	\$0.16	\$19,841.63
Total				\$41,159.22
Operating Cost				
Energy - Air pump	kwh	4,873	\$0.08	\$413.23
Energy - Water pump	kwh	7,776	\$0.08	\$659.40
Energy - Lights	kwh	41,472	\$0.08	\$3,516.83
Energy – Greenhouse heating/cooling	kwh	17,520	\$0.08	\$1,401.60
Seeds - Lettuce	lettuce	24	\$8.00	\$192.00
Seeds - Basil	packet	24	\$4.00	\$96.00
Seeds - Washington cherry tomato	packet	24	\$4.20	\$100.80
Hydro-Gro Vine		12	\$126.00	\$1,512.00
Potassium nitrate		12	\$69.00	\$828.00
Hydro-Gro Leafy Greens		12	\$126.00	\$1,512.00
Clay pebbles	40 L	24	\$28.00	\$672.00
Net pots	50 pots	24	\$23.20	\$556.80
Labor	hours	1,440	\$10.00	\$14,400.00
Chemicals (sulfuric acid)	L	11	\$26.74	\$288.79
Water	gallon	288	\$4.80	\$57.60
Germination trays	unit	12	\$17.95	\$215.40
Total				\$26,422.45
Annual Profit				\$14,736.78

Table 5 – Financial results for aquaponics and hydroponics

Results	Hydroponics	Aquaponics non-organic prices	Aquaponics 10% veg. prices increase	Aquaponics 20% veg. prices increase	Aquaponics 30% veg. prices increase
Annual IRR (%)	302	107	200	293	386
NVP (\$)	77,846	27,596	54,899	82,202	109,505
Payback (years)	1.35	1.99	1.53	1.36	1.27
Benefit/Cost	1.53	1.26	1.38	1.51	1.63

Table 6 – Annual production and operating cost for a small representative farm

Production	Unit	Total (year)	%
Fish -Tilapia	lb	5,000	17.48
Basil	lb	20,000	69.93
Specialty - Peppers	lb	3,600	12.59
Operating cost			
Fingerlings	\$	\$750.00	0.59
Feed	\$	\$2,700.00	2.12
Plant/fish disease management	\$	\$144.00	0.11
Micronutrients	\$	\$9,000.00	7.08
Seeds/Seedlings	\$	\$1,200.00	0.94
Energy	\$	\$15,600.00	12.28
Water	\$	\$240.00	0.19
Natural Gas	\$	\$4,800.00	3.78
Labor	\$	\$84,000.00	66.10
Transportation cost to market	\$	\$1,440.00	1.13
Repairs/maintenance	\$	\$1,200.00	0.94
Machinery/Equipment	\$	\$1,800.00	1.42
Business consulting	\$	\$3,000.00	2.36
Advertisement	\$	\$1,200.00	0.94
Total operating cost	\$	\$127,074	100

Table 7 – Annual production and operating cost for a medium representative farm

Production	Unit	Total (year)	%
Fish -Tilapia	lb	10,000	20.00
Basil	lb	40,000	80.00
Operating cost			
Fingerlings	\$	\$1,500.00	0.94
Feed	\$	\$5,400.00	3.37
Plant/fish disease management	\$	\$114.00	0.06
Micronutrients	\$	\$8,550.00	4.68
Seeds/Seedlings	\$	\$1,710.00	0.94
Energy	\$	\$28,500.00	15.60
Water	\$	\$674.09	0.37
Natural Gas	\$	\$6,740.85	3.69
Labor	\$	\$114,000.00	62.39
Transportation cost to market	\$	\$3,420.00	1.87
Repairs/maintenance	\$	\$684.00	0.37
Machinery/Equipment	\$	\$2,022.26	1.11
Business consulting	\$	\$5,617.38	3.07
Advertisement	\$	\$2,808.69	1.54
Total operating cost	\$	\$181,741	100

Table 8 - Annual production and operating cost for a large representative farm

Production	Unit	Total (year)	%
Fish -Tilapia	lb	20,000	20.00
Basil	lb	80,000	80.00
Operating cost			
Fingerlings	\$	\$3,000.00	0.83
Feed	\$	\$10,800.00	3.00
Plant/fish disease management	\$	\$4,750.00	1.32
Micronutrients	\$	\$14,000.00	3.89
Seeds/Seedlings	\$	\$6,300.00	1.75
Energy	\$	\$40,000.00	11.10
Water	\$	\$1,000.00	0.28
Natural Gas	\$	\$10,000.00	2.78
Labor	\$	\$240,000.00	66.60
Transportation cost to market	\$	\$3,500.00	0.97
Repairs/maintenance	\$	\$8,000.00	2.22
Machinery/Equipment	\$	\$4,000.00	1.11
Business consulting	\$	\$10,000.00	2.78
Advertisement	\$	\$5,000.00	1.39
Total operating cost	\$	\$360,350	100

Table 9 – Annual total profit with tilapia and basil prices (specialties peppers price at \$10/lb for small farms)

Tilapia prices (\$)	Basil prices (\$)						
	3.00	3.50	4.00	4.50	5.00	5.50	6.00
	Small farm						
1.75	-\$22,324	-\$12,324	-\$2,324	\$7,676	\$17,676	\$27,676	\$37,676
2.00	-\$21,074	-\$11,074	-\$1,074	\$8,926	\$18,926	\$28,926	\$38,926
2.25	-\$19,824	-\$9,824	\$176	\$10,176	\$20,176	\$30,176	\$40,176
	Medium farm						
1.75	-\$44,241	-\$24,241	-\$4,241	\$15,759	\$35,759	\$55,759	\$75,759
2.00	-\$41,741	-\$21,741	-\$1,741	\$18,259	\$38,259	\$58,259	\$78,259
2.25	-\$39,241	-\$19,241	\$759	\$20,759	\$40,759	\$60,759	\$80,759
	Large farm						
1.75	-\$85,350	-\$45,350	-\$5,350	\$34,650	\$74,650	\$114,650	\$154,650
2.00	-\$80,350	-\$40,350	-\$350	\$39,650	\$79,650	\$119,650	\$159,650
2.25	-\$75,350	-\$35,350	\$4,650	\$44,650	\$84,650	\$124,650	\$164,650

Table 10 – Total investment required to get a zero NPV according to different tilapia and basil prices (specialties peppers price at \$10/lb for a small farm)

Tilapia prices (\$)	Basil prices (\$)						
	3.00	3.50	4.00	4.50	5.00	5.50	6.00
	Small farm						
1.75	-\$210,604	-\$116,264	-\$21,925	\$72,415	\$166,755	\$261,094	\$355,434
2.00	-\$198,811	-\$104,472	-\$10,132	\$84,208	\$178,547	\$272,887	\$367,226
2.25	-\$187,019	-\$92,679	\$1,660	\$96,000	\$190,340	\$284,679	\$379,019
	Medium farm						
1.75	-\$417,370	-\$228,691	-\$40,012	\$148,667	\$337,347	\$526,026	\$714,705
2.00	-\$393,785	-\$205,106	-\$16,427	\$172,252	\$360,931	\$549,611	\$738,290
2.25	-\$370,201	-\$181,521	\$7,158	\$195,837	\$384,516	\$573,196	\$761,875
	Large farm						
1.75	-\$805,189	-\$427,830	-\$50,472	\$326,887	\$704,245	\$1,081,604	\$1,458,962
2.00	-\$758,019	-\$380,660	-\$3,302	\$374,057	\$751,415	\$1,128,774	\$1,506,132
2.25	-\$710,849	-\$333,491	\$43,868	\$421,226	\$798,585	\$1,175,943	\$1,553,302

Figure 1: Operational Cost of Aquaponics Experiment

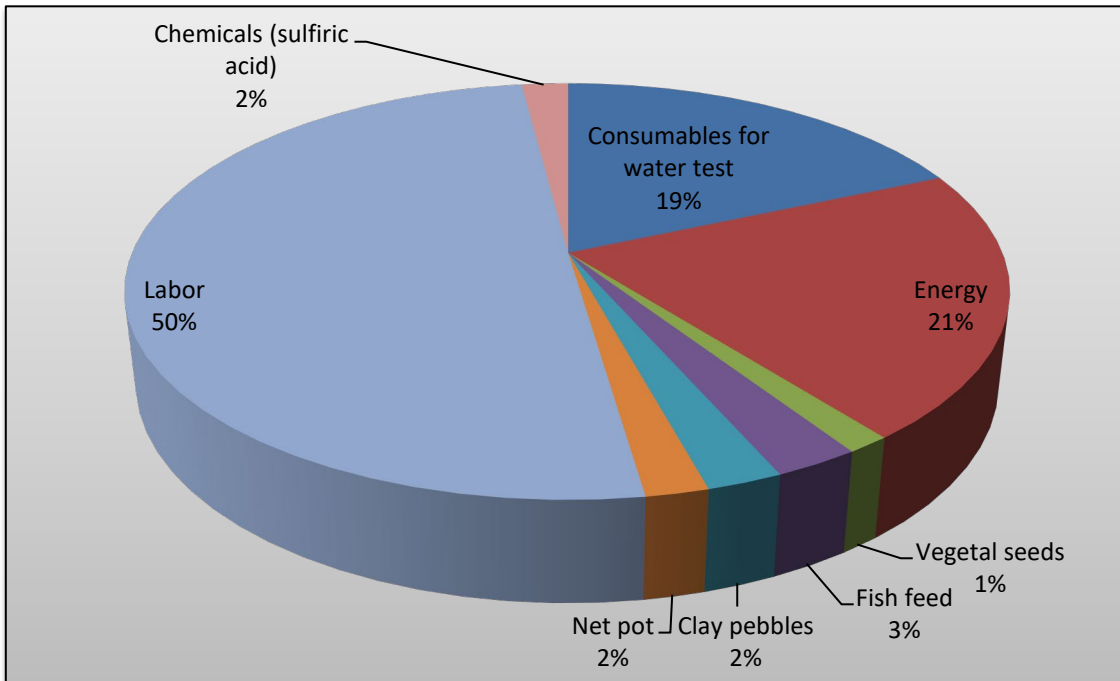


Figure 2: Operational Cost of Hydroponics Experiment

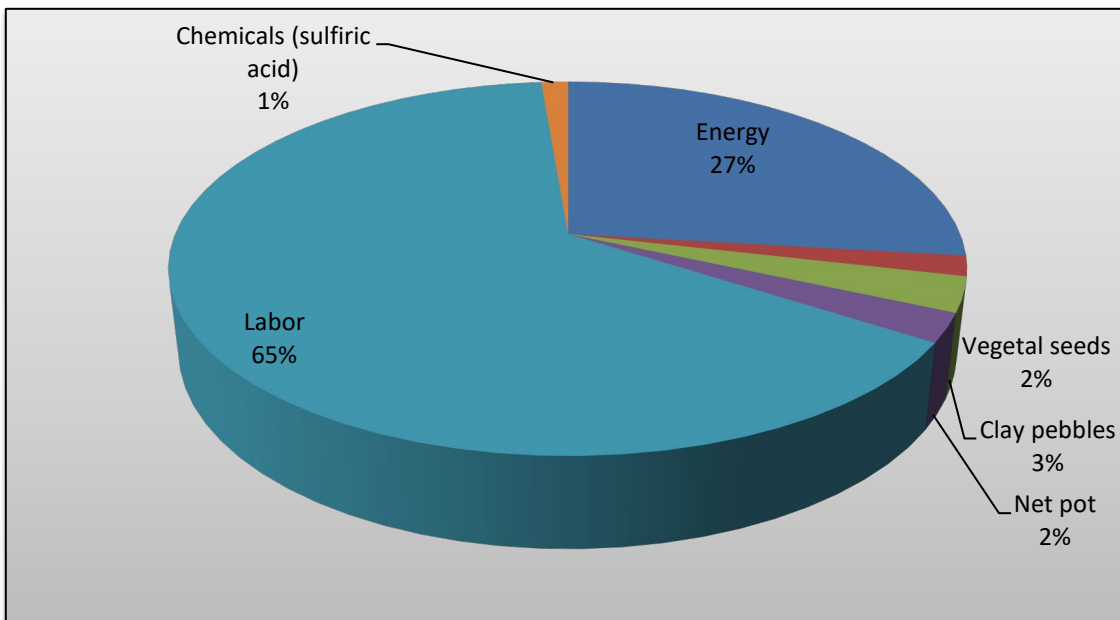
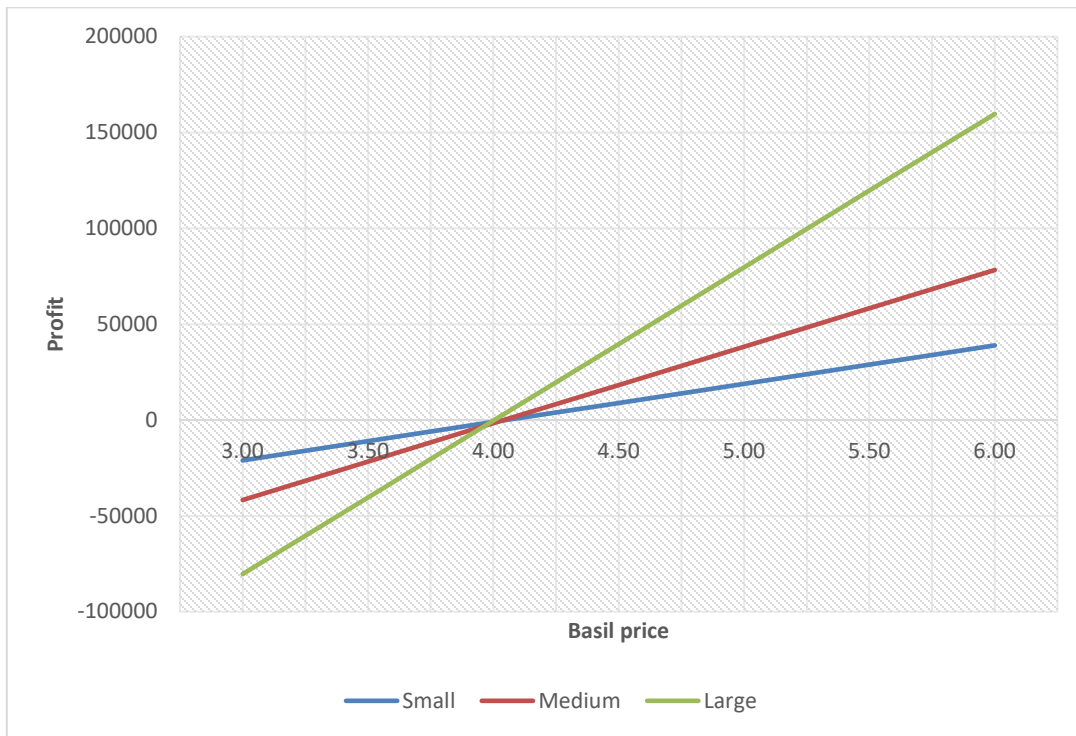


Figure 3 - Profit according to basil prices - \$ (Tilapia at \$2.00)



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