Eco-granjas “Michín”, S.A. de C.V.

Introduction

In October 2018 engineer Mauricio Aguilera was reviewing the financial forecasts of a tilapia production project. It was an aquaculture project just 20 minutes away from the airport in Tuxtla Gutiérrez, the capital city of the state of Chiapas in Mexico. Despite being a new venture in an activity in which neither Mauricio nor his advisor/partner Dr. Félix Laínez had previous experience, both had very good technical and managerial knowledge as well as relevant, long-time practice in agriculture. To meet this special need for knowledge and experience in fish farming, they had begun a relationship for support and advice with Acuícola Garza, a company operating in Yucatan, with experience and a strong scientific background in tilapia production in Mexico.

Mauricio and Félix planned to create an innovative, well-managed and eco-efficient company. To do so they were installing solar panels to have a source of clean, 100% renewable energy. In addition, they were installing a Biofloc feeding system that would not only decrease the significant feeding costs in that activity, but also would improve the health and nutrition conditions for tilapias. "The idea is to create an eco-farm with a very efficient, closed system, and low-cost technology. Once the business model was validated, the idea was to replicate it in other locations or offer advice to other investors wishing to have a sustainable, innocuous model," Mr. Aguilera said to Dr. Laínez. The latter, his former classmate at the irrigation major in Universidad Autónoma de Chapingo (UACH) in the state of Mexico, was also his partner and advisor. Dr. Laínez replied: “I agree. Plus, I believe it is better for us to start small to acquire know-how and then progressively move to a sustainable business model, with hormone-free tilapias.”

The farm already had the eight ponds to start the project. While walking there, Laínez said to Mauricio, "... We must understand the critical variables in this new business we just started and be clear about the business model to pursue." In relation to this and in order to start generating income, Mauricio told Félix about systems involving lower investment. "We better check our options more carefully," Mauricio said. "We cannot afford to fail since capital is such a scarce resource for us." To this Félix replied: “We are interested in having a more complete picture of the project’s risks and financial returns. So, we have to work with the flows once the critical variables and their parameters are identified."

Tilapia production systems

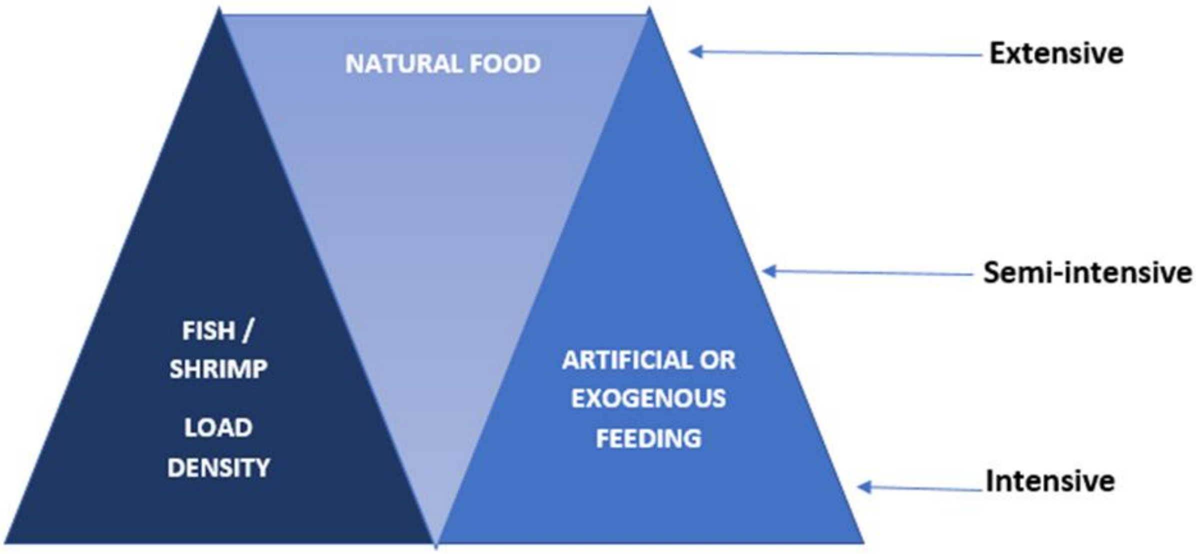
The tilapia species to be produced in the first ecological fish-farm was Nile Tilapia (***Oreochromis niloticus***). So far there were three types of production systems: semi-intensive, intensive, and super-intensive system or Biofloc[1] for commercial production in aquaculture farms. The semi-intensive system required lower power consumption than the other two as it involved fewer water replacements, lower fish density, and fewer harvests. Estimated payback time with this system was six years. On the other hand, the intensive system required more energy due to frequent water exchange and higher density of fish. Estimated payback time with this production system was four years.

Figure 1 sketches the three production systems. The extensive system relies more on natural feeding and low fish density, which makes it lower cost. On the other hand, intensive systems (just like super intensive systems not shown in the figure) use prepared food, and can withstand much higher fish densities, but then they can be expensive.

[1] Biofloc is the productive unit of biofloc technology. It consists of substrate colonized by different microorganisms allowing water to recycle. In this system fertilization and oxygenation are required so that microorganisms are always active in the system. Biofloc technology is based on operating the pond with minimum or zero water exchange, subsequent development of a dense microbial population, and management of that population by adjusting the carbon / nitrogen ratio to control the concentration of inorganic nitrogen in water.

Figure 1

Three basic types of tilapia production systems types



Aquaculture had grown rapidly over the last decade; however, the increase in aquaculture production worldwide was thought to be restricted by the requirements of abundant, good quality water and the availability of land fit for this activity. In view of these restrictions, intensive systems were seen as a viable, environmentally friendly way to increase aquaculture production. However, establishing appropriate intensive systems to produce tilapia under optimal conditions was limited by the need for additional investment and by potentially high operating costs. This put pressure on producers due to the need to produce tilapia at a lower cost than the prevailing market price. Biofloc technology (BFT) was chosen since it was seen as a system allowing for intense production with reasonable investment and operating costs.

Figure 2

Tilapia production systems types and characteristics

Extensive System	Semi-intensive System	Intensive System	Super-intensive System
• No aeration • Daily water replacement (up to 10 times) • No balanced diet • Low biomass /density (<10 kg / m^3)	• May/may not have aeration. • Balance diet starts. • Lower fish density (10-15kg / m^3)	• Mandatory aeration • Higher fish density (15kg-25kg / m^3) • Water replacement needed (60% - 100% per week) • More food required	• Mandatory aeration • Densitiy above 30 kg / m^3; may reach up to 50 kg / m^3. Seen as high-biomass systems. • In biofloc systems, biofloc can replace up to 20% of total food.

Ecogranja had chosen to use the Biofloc system. This system required constant aeration of ponds due to the higher density of planting, but it did not consider water exchange. Payback time could vary depending on design engineering, but the estimated break-even point was approximately 13 months with two harvests per year.

Biofloc's prebiotic effect was believed to help strengthen the fish immune system. In addition, it offered other advantages including a 90-99% reduction of water exchange and the production of biomass to feed fish. It was thought that through the use of this technology production could increase between 20 and 30kg/m2 as compared to conventional production.

Production growth

Tilapia growth was estimated daily, but biometrics was performed every two weeks for exact measurement.

The first harvest took 6 months from sowing to harvest, but continuous production could then be obtained through staggered sowing since all factors were controlled. Therefore, there was talk of monthly production from the first harvest on. Production scheduling depended on market demand or contracts with target markets that also specified the target weight for tilapia harvest.

In April 2019, it was decided to conduct an exploratory study of the potential market for the project. It was carried out through visits and face to face interviews on April

10-12 in four markets in Tuxtla Gutiérrez, the capital city of the state of Chiapas. Although modest, this study improved the prospects for both the product and the target market. The fish would be sold without offal and it would be delivered two or three times per week at the customer's place. Both the study and conversations with retailers showed that people in Chiapas preferred fish weighing 200-300 grams. As a result, it was not necessary to wait for six months for the first harvest. This was good news as the original plan included obtaining 500-grams tilapias after six months. Harvesting and selling it ahead of schedule would have a positive impact on the cash flow of the project, according to Félix Laínez. Mauricio agreed and added that adapting production to customer preferences would shorten the production cycle and reduce costs.

The tilapia industry

Aquaculture had experienced significant growth over the last few years. Both marine and freshwater fishery resources were no longer considered sufficient to meet the demand of a market still growing. Many of the world's largest fisheries were being exploited beyond the Maximum Sustainable Yield (MSY) threshold. As a result, the population of fish in the world oceans had decreased and therefore fishing efforts, including costs, had increased over the last few decades. MSY was the point with the maximum resource growth rate; catches beyond this point would result in decreased fish stocks under the open access regime, i.e., in the oceans.

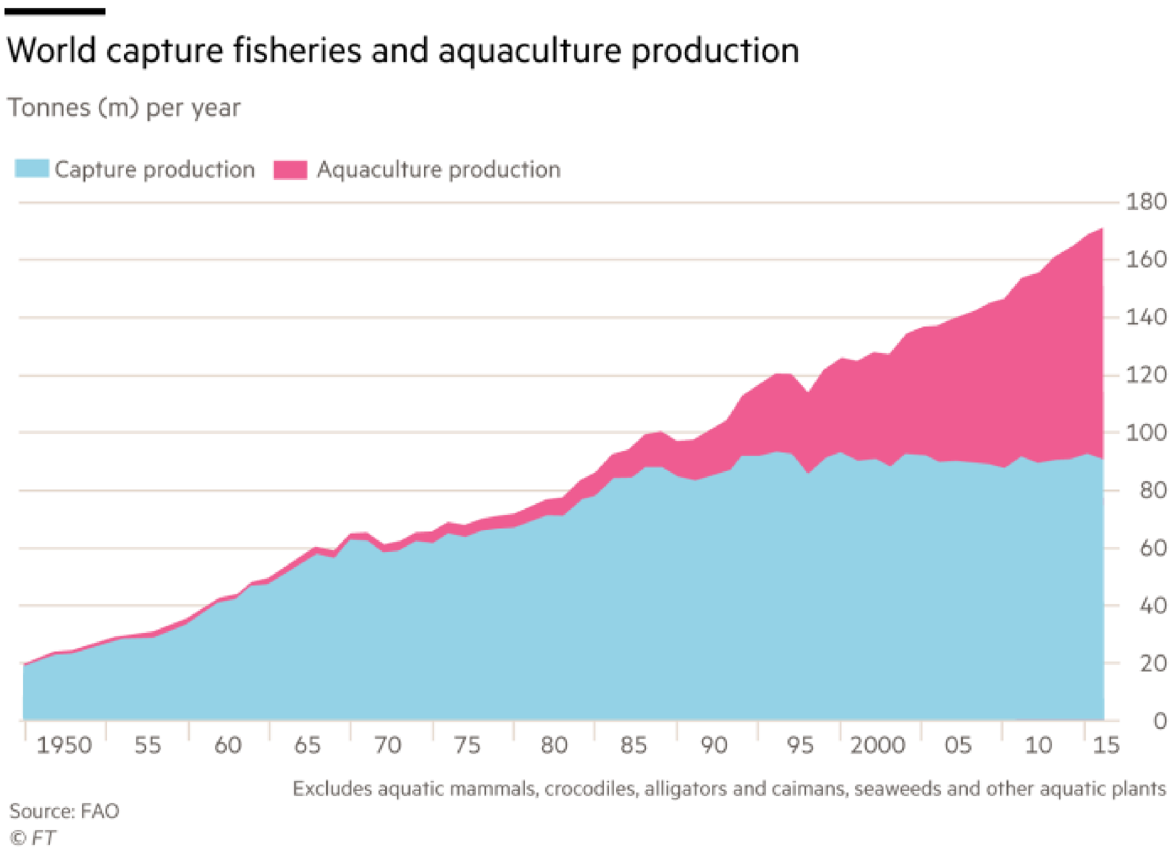
Worldwide fishing production had topped at approximately 171 million tons by 2016, with aquaculture representing 47% of the total and up to 53% if non-food uses of fishing resource were excluded (including preparing fish flour and oil).

The total value of fish production in 2016 was estimated at US$ 362 billion, of which US$ 232 billion came from aquaculture. Given the low annual growth of capture fishing since in the oceans in since the late 80s, aquaculture had been the trigger for the impressive continuous growth of fish supply for human consumption.

Figure 3 shows this statistic for 1950 - 2015. Notice the point in time from which an impressive growth in aquaculture takes place.

Figure 3

World Catch in Fisheries and Aquaculture Production



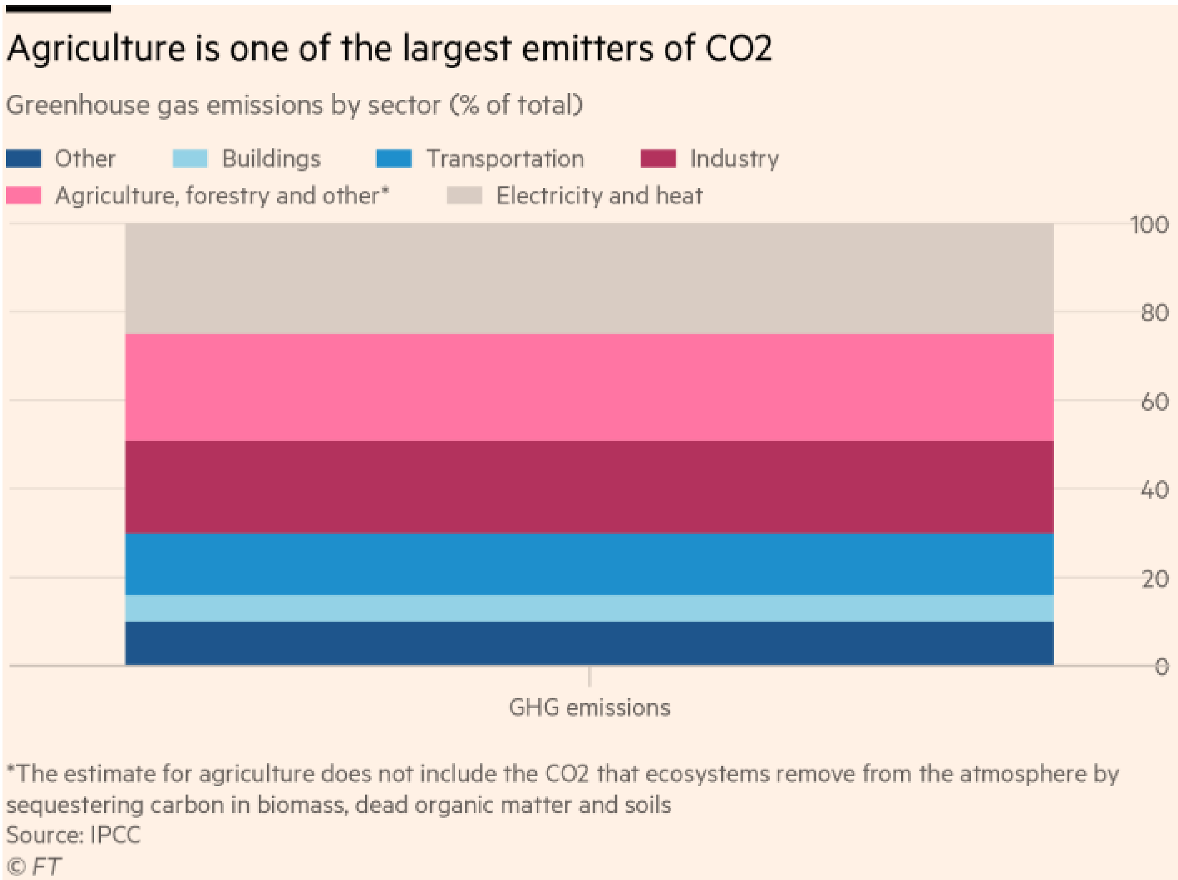
The rise in aquaculture was said to have been one of the greatest revolutions in food production in the second half of the twentieth century, with global production growing from below 2.5 million tons in 1970 to over 80 million tons in 2018, according to UN data (Financial Times, January 2019).

It was also thought that the increase in supply had helped make fish and seafood more accessible to consumers around the world. It had also helped democratized the consumption of these goods that were no longer seen as luxury goods. For environmentalists and long-term vision producers, aquaculture had come to relieve pressure on fish stocks in fisheries around the world, many of which were overexploited. However, a 2019 global review of the fishing industry published by FAO (United Nations Food & Agriculture Organization) showed that the production of aquaculture farms was slowing down.

According to this source, annual expansion in global aquaculture would go from 5.7% in 2003 - 2016 to only 2.1% between 2017 and 2030 mainly due to lower growth of inland aquaculture in China's huge fish farms.

Figure 4

Agriculture and CO_2 emissions



This meant that the growth of aquaculture between the mid-2010s and the early 2020s would only meet 40% of the expected increase in global fish demand, leaving a supply/demand gap of approximately 28 million tons. According to FAO, aquaculture must grow 9.9% a year to bridge the global fish gap. This gap would not only account for increased pressure on ocean fisheries, which were already overexploited or at maximum levels in terms of sustainable exploitation/harvest, but also moving to more carbon-intensive forms of food production, bringing about concern from environmentalist groups around the world.

Agriculture (Figure 4) was said to be the main source of greenhouse gases. On the other hand, conventional ocean fishing had significant capital requirements which included burning fossil fuels. According to sources cited by FAO (see above), aquaculture accounted for just 5% of greenhouse gas emissions associated to climate change resulting from agriculture. This evidence encouraged Dr. Laínez significantly, as he was persuaded of the need to make a radical change in agricultural practices towards sustainable aquaculture.

China was the largest producer of tilapia worldwide and the main competitor for low-cost producing countries. On the other hand, tilapia had captured a large market share in developed countries, especially in the United States and, to a lesser extent, in the European Union. In addition, China was increasingly exporting significant quantities of tilapia to several African countries.

Average nominal prices of fish in the market were expected to continue increasing 0.8% per year, with an expected 7.3% growth by 2026 compared to the base 2014-2016 period. In addition, average nominal prices for aquaculture and marine species were expected to remain relatively stable or decrease slightly until 2020, before starting to grow again until 2026.

Nominal prices of fishmeal and fish oil would maintain an upward trend with growth rates of 3.4% and 2.0% per year, respectively. Total fish production worldwide was estimated to grow by just over 1% per year, a substantial reduction in relation to 2.4% per year, the average growth rate for the previous decade.

Due to its demographic growth, the state of Chiapas in Mexico required large amounts of food, especially aquaculture products as a source of low-cost protein with high nutritional value. Statewide demand was considered to be very strong.

In spite of the above, which according to various opinions meant good opportunities to diversify production taking advantage of Mexico's very large Atlantic and Pacific coastlines (figure 5), in addition to reservoirs and several states with good water balance, the development of aquaculture in Mexico, compared to aquaculture development worldwide, showed a lag in both diversity and use of resources as well as in sector modernization.

Figure 5

Map of Mexico

In 2018, Mexico ranked ninth among tilapia producers worldwide, with 163,714 tons per year worth approximately US $ 14.7 million. The state of Jalisco produced a little more than 34,000 tons, Chiapas 26,621 tons, and Michoacán 23,954 tons. On the other hand, the Mexican states with the greatest growth in 2015-2016 were Sonora (which tripled its production), Quintana Roo, Tamaulipas, Querétaro, Durango, Sinaloa, Oaxaca, and Yucatán.

Mexico's trade balance in 2016 showed fish and shellfish imports worth US $ 1,090.4 million (396,324 tons), with exports of US $ 1,013.6 million (189,806 tons). Tilapia ranked first in imports with U $ 225.2 million (19%), followed by shrimp, US $ 169.5 million (14%), tuna and the like with US $ 146.7 million (12%), Basa fish (a kind of cat-fish), US $ 129.1 million (11%) and salmon with US $ 116.6 million (10%).

These imports originated in China with US $ 409.8 million (34%), Chile, US $ 148.4 million (12%), Vietnam, US $ 147.2 million (12%) and the United States, with imports worth US $ 99.5 million (8%). On the other hand, the main species exported included shrimp, US $ 314.1 million (31%), tuna, US $ 182.5 million (18%), lobster, US $ 71.9 million (7%) and fish and shellfish flour US $ 57.7 million (6%). Exports went to the

United States, US $ 585.9 million (58%), Japan, US $ 97.4 million (10%), Hong Kong, US $ 94.4 million (9%) and Spain US $ 60.6 million (6%).

The Mexican market

Most hotels and restaurants in Chiapas bought whole, eviscerated fish and fillet. Although Chiapas was the leader in the production of tilapia in Mexico, a large part of the production was in the hands of a foreign company and was fully marketed outside Mexico. In 2016, the production of Nile tilapia in Chiapas amounted to 38,313 tons distributed among approximately 250 producers throughout the state. According to Chiapas' Council of Aquaculture (March 2017) there was a high unmet demand for the product, especially of local and regional.

At the date of writing the case, cooperative and individual farms operating in Chiapas produced Nile tilapia mainly in cages placed in reservoirs such as Malpaso, Peñitas, La Angostura, Salto de Agua and La Concordia. In general, most of the production took place in floating cages in reservoirs and very little in ponds or tanks.

Fish trade in Mexico took place through three large supply channels: supply centers, supermarkets, and self-service stores. Fish was also sold in hotels, restaurants, and banquets. At the date of writing the case there were 12 markets offering fish and seafood. The Mercado del Mar in Jalisco and the Mercado de la Nueva Viga in Mexico City sold 30,000 and 170,000 tons of fish per year, respectively.

At the time of writing the case study, Eco-Granjas Michín had letters of intention to purchase written by clients interested in obtaining tilapia produced using the Biofloc technology. Average per capita consumption of tilapia in Mexico was approximately two kilograms per year and tilapia was highly valued because of its high nutritional value. Each 100 grams of tilapia contained 20 grams of protein, 1.7 grams of fat, 96 calories and 50 milligrams of cholesterol, in addition to minerals such as potassium, phosphorus and sodium and vitamins B3, B9 and D.

According to CONAPO data (National Population Commission), fish consumption in Mexico was expected to grow about 1.3% per year, with tilapia among the main species to consume. Although it was said the fish consumption in Mexico would maintain constant growth, demand was not fully met so imports were required.

A major reason for the production deficit was the lack of a significant number of large, well-financed companies. Many producers were small and did not have good quality financing and technical assistance. Aquaculture in Mexico was expensive in terms of both investments and operating costs. This scenario was still more serious in southern Mexico, where the state of Chiapas was located. However, Chiapas was among the largest producers of tilapia (popularly known as "mojarra") in Mexico.

This structural problem was believed to result in the country losing the opportunity to participate in an expanding world market. World fisheries production (including fish, crustaceans, mollusks, and other animals but excluding reptiles and mammals as well as algae and other plants) had topped at approximately 171 million tonnes in 2016. Aquaculture accounted for 47% of the total and 53% if food uses were not excluded (including reduction to prepare fish flour and oil).

Given the plateau in the production resulting from ocean fishing since the late 1980s, aquaculture had been the trigger for the continued growth of fish supply intended for human consumption. Between 1961 and 2016, the average annual increase in world consumption of edible fish (3.2%) exceeded population growth (1.6%) as well as the consumption of meat of all land animals (2.8%). Per capita consumption of edible fish increased from 9.0 kg in 1961 to 20.5 kg in 2017.

The Project

The project was based on intensive farming of tilapia by building and operating a super-intensive Nile Tilapia farm (Oreochromis niloticus) with no water exchange at a plot owned by Mr. Aguilera in El Ejido Nicolás Bravo, Chiapa de Corzo, in Chiapas, southern Mexico.

The Eco-Granjas Michín project consisted in creating an aquaculture farm to produce and selling tilapia, by applying good production practices according to protocols established in the 2008 Manual of Good Practices of Aquaculture Production of Tilapia for Food Safety. This manual was published by SAGARPA (Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food) in Mexico.

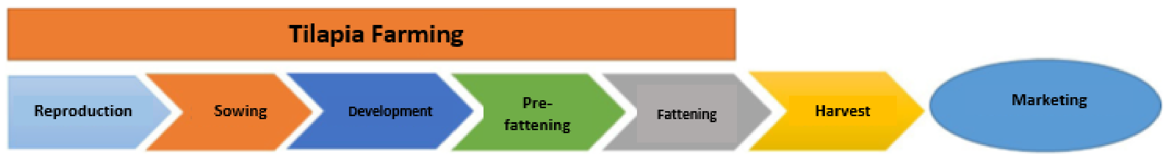
Although the existence of great market demand was known, the most difficult barrier to overcome was producing tilapia with the expected quality and then position the company in an attractive market in view of project characteristics. Restrictions for this type of projects were thought to relate mainly to project scale, lack of continuous supply, and poor standardization of product.

The project included installing 10 fattening tanks, two pre-breeding tanks, and two acclimatization tanks, all of them built with polypropylene geo-membrane, and a pond excavated on the ground. This system required little water exchange in the ponds, accounting for significant energy savings although constant aeration ("blowers") was needed. Thus, a low-cost power source was ideal. On the other hand, due to increased sowing density, a larger number of fry sown in four cycles (unfolding) of stepped sowing during the first year was needed. As of the second year, the number of cycles would rise to six. In each cycle, 7,125 tilapias originally thought to weigh half a kilogram each would be harvested. Considering a survival rate of 99%, the total number of fry to sow per tank was 7,917. Taking into account a 10% loss in transportation, 8,708 little fish per tank would be bought. Tanks and ponds in the project amounted to 1,208 square meters.

For a production chain diagram from fry production to tilapia marketing see Figure 6 below.

Figure 6

Major Participants in the Tilapia Agribusiness System



Fuente: (COESA, 2011)

The estimated investment required to carry out the project amounted to $ 5,307,463.72 M.N. (1US $ = 19.34 pesos as of March 12, 2019). This figure included initial working capital, civil works for lab and offices (production infrastructure), aquaculture equipment, hydraulic facilities, and aeration and other equipment. Organizational pre-operative expenses such as training/advice and technical assistance early in the project were also included (see Exhibit 1). The figure also included initial working capital.

Ten permanent staff members and 15 temporary workers to harvest, unfold, and other activities would be hired. The project was thought to clearly and precisely the good management of water and farm waste.

Estimated income from the sale of 36.13 tons of fish, with a variable production cost of $ 27.4 pesos/kg from first year on, amounted to 1,806,500 Mexican pesos. For the second year, a volume of 54.20 tons was considered, with a variable production cost of around $ 21.00 pesos/kg. From year 3 to year 10 revenue would grow 5% per year. No change in price was considered for the 10-year horizon set to evaluate the project in the basic scenario.

Four sowing cycles were considered for the first year and six cycles from year 2 on. The food cost per batch of 6 cycles was estimated to be 162,986.35 Mexican pesos. This cost was broken down by lot as shown in table 1 below.

Table 1

Feeding costs per batch of fish

SUMMARY	$	
1 MONTH	$ 8,533.00	
2 MONTHS	$ 6,248.72	
3 MONTHS	$ 15,403.63	
4 MONTHS	$ 32,031.09	
5 MONTHS	$ 41,298.40	
6 MONTHS	$59,471.50	
TOTAL / LOT	$ 162,986.35	

Exhibit 4 shows the project's production costs as originally projected. In this regard, Dr. Laínez said; "… Mauricio, I think that in spite of the initial five-year forecasts made under the SAGARPA format, most assets have not depreciated over that time and the project has just begun to show stable flows of operating cash. So, I think it would be worth considering if we expand the analysis horizon to 10 years as an ongoing project." The project would generate 10 fixed jobs and zero water discharges to surface water bodies. The saving of water consumption in production was estimated at 50% compared to traditional production.

Table 2
Ponds to use per farm section

Stage	Number of tanks per module	Dimension	Unit	Tank area (m2)	Tank volume (m3)	Module area	Module volume
Pre breeding	2	7	m Diameter	38.5	46.2	77.0	92.4
Breeding	4	12	m Diameter	113.1	135.7	452.4	542.9
Fattening	6	12	m Diameter	113.1	135.7	678.6	814.3

The project included purchasing 12 geo-membrane ponds (Table 2) 1 mm thick and building an oxidation tank. The estimated fattening period would be 6 months, with harvests taking place when the fish reach350 - 500 grams on average, depending on market conditions and customers' preferences. Harvests would be staggered, with four harvests in the first year (approximately 37 tons per year) and six harvests in year two (55 tons), 58 tons in the third year, 61 in the fourth year, and 64 in the fifth year. From year six on harvests would level at 65 tons.

Table 3 shows this income forecast for the first five years. Forecasts were made considering a 5% annual growth rate in sales volume. Calculations had been made at a constant price of $ 50 / kg during the analysis period, although it was believed that this price could fluctuate between $ 51 and $ 54 per kilogram.

Table 3
Eco-Granjas Michín
Project income forecast – years 1-5
(Figures in Mexican pesos)

	YEAR	YEAR	YEAR	YEAR	YEAR
Item	1	2	3	4	5
Sales revenue	$1842,823.91	$2764,235.87	$ 2902, 447.66	$ 3047,570.05	$ 3199,948.55
Tons	37.00	55.00	58.00	61.00	64.00
TOTAL	**$1842,823.91**	**$2764,235.87**	**$ 2902, 447.66**	**$ 3047,570.05**	**$ 3199,948.55**

The super-intensive Biofloc farming system (Exhibits 5 and 7), would allow for 1: 1 feed conversion, thus contributing to save food which accounted for the main expense in aquaculture systems. Survival was expected to be over 90%, with high growth rates due to the presence of the microbial florets. In addition to ponds, an office, a guardhouse, a food storage facility, and the engine room would be built. The pond area would be divided into three sections: pre-breeding, breeding, and fattening sections. At the end of each cycle, the water would be poured into the treatment pond to be re-used in the next cycle. This procedure would allow reusing the water for a 4 - 5 years. Exhibit 3 itemizes fixed assets, their annual depreciation rates, the value of annual depreciation and residual values.

Working capital required in year one had been estimated in $731,340.22 and $186,935.30 in year two. Working capital would be paid back in full at the end of the project's life. By evaluating the profitability of the going concern, flows were estimated to grow in perpetuity by the end of the analysis period at a growth rate of 5%. Tax rate was 30%. It was thought that, given the project’s social attractiveness, up to 80% of project cost could be funded with debt (including working capital); 20% would be funded through equity. Revenue would increase 5.8% per year (according to the annual growth rate of inland aquaculture). The cost of debt after taxes was estimated at 8.3% in local currency. The rest would be financed with equity with an estimated financial cost of 12%.

Product

The project would consist of nurturing Nile tilapia (Oreochromis niloticus). This fish was endemic of Africa but due to its ease of adaptation it was widely spread throughout tropical and subtropical areas around the world, with very broad adaptability to different types of water, which made it ideal for fish farming.

Producing tilapia was more profitable than raising other species, as it required less food. Nile tilapia only needed 1.2 kg of food (with Biofloc technology one kilo or less) to produce 1 kg. of fish with high nutritional value. On the other hand, cattle needed 8 kg., sheep 5 kg. and fowl 2 kg to produce one kilogram of meat.

Among other advantages, tilapia was among poikilotherms (cold-blooded animals), resulting in more meat as they did not need as much energy as other animals did. In addition, they were resistant to diseases, and easy to feed and reproduce. Tilapia also had comparative advantages as compared to other white meat competing species (hake and cod), as the latter showed a decreasing harvesting trend since they were basically marine species.

It was said its taste was between hake and trout. Its meat was white, firm and quite lean, with less than 1.3% fat and low in cholesterol (50 mg/100g of fillet). In addition, it had a very low salt content (34 mg of sodium/100 grams) and calories (82 calories/100 grams of fillet).

The product could be sold at farm gate price, to be brought to processing plants; either whole or eviscerated to restaurants or markets where it will be sold or consumed. Finally, it could be sold alive. To take the product to another site after harvest, a refrigerated truck with temperature control was needed. Other forms of transportation included polyurethane boxes with ice.

The muscle portion of the fresh, healthy, clean, fish without its belly would be sold, either with or without skin and scales, according to the presentation desired, obtained by a cut parallel to the spine and subjected to quick freezing, able to produce a temperature of -18 ° C (0 ° F) at its thermal center.

In addition, the product should also be reasonably free of torn ends, tears and fins, discolored flesh, and blood clots. It should also be free of deep dehydration (burn caused by the refrigerator) that could not be easily removed by scraping.

Color should be uniform, free of foreign shades due to contamination or alteration, free of strange/unpleasant odors resulting from contamination, alteration, or adulteration. Its texture had to be firm, elastic, or typical of the species.

The project would not handle labeling, packaging, wrapping, storage, and transportation, since the farm intended to sell fresh whole fish with buyers responsible for transportation and compliance with hygiene standards. However, both Aguilera and Laínez had agreed to build evisceration facilities since the final product would be brought to customers eviscerated and frozen.

"Eco-farms" were seen as a sustainable, innovative alternative compared to traditional production in Mexico and other countries. They met environmental requirements through proper water management and reduction of activities harming the environment. In addition, they were a production alternative to reduce over-exploitation of marine fishing resources. From an economic standpoint, it would be a profitable project to ensure income for farm partners and employees. Finally, from the social standpoint, jobs would be created at the local and surrounding communities, serving as a "best practice" model to encourage other aquaculture producers in Chiapas.

Distribution and sale channels

Sale channels at the date of writing this case study were:

At the date of writing the case study, these included:

i. Fishmongers: With exclusive sale of fresh and frozen products, able to sell directly to producers and intermediaries
ii. Hotel and restaurant suppliers: these bought tilapia directly from producers at a good price, thus eliminating intermediaries.
iii. Other buyers: they handled a wide range of products, including fresh as well as frozen fish; they had transport and distribution infrastructure.

Direct promotions to towns near the farm were planned. Other sales and distribution strategies considered included:

i. Creating a web page and using social media to advertise company products.
ii. Signage and outreach to publicize the product in surrounding communities.
iii. Agreements with hotel entrepreneurs or intermediaries engaged in purchasing tilapia.
iv. Local tasting events to make the product known.
v. Attending state government-sponsored events to promote aquaculture activities.

Supply Chain

Purchase of inputs.

i. Fry.

Fry would be purchased from Acuacultra Integral de San Miguel S. de R.L. de C.V., a company located at Km 1, Baca-Tixcuncheil state highway in Yucatán. This company distributed tilapia fingerlings with hormones (Oreochromis sp.) with SAGARPA certificate of origin and import permit. Oreochromis sp. was an F1 fattening variety (the first generation of fish) and its sexual reversal efficiency was estimated to be 98%. In aquaculture it was customary to work with populations of a single sex for rapid growth and reproduction control to canalize food energy to produce body mass.

Fry unit cost was $ 1 per fingerling. The project had plans to acquire 17,400 fingerlings approximately every two months. With a six lots per year the estimated annual cost was $ 104,500 M.N. See Exhibit 6 for a series of tables related to fry purchase and development.

ii. Food

The food used in the project was WINFISH from Zeagler, distributed by PROVI, a specialized food company located in Mérida, Yucatán. According to plans, food with an estimated cost of $ 162,986.35 pesos per production lot would be used per production cycle. Food protein content is shown in table 4 and feeding costs in Exhibit 6.

Table 4
Food and protein percentage
(Prices in Mexican pesos)

NAME	% PROTEIN	PRICE PER BAG	PRICE PER KG
WIINFISH 4010 25 KG BAG	40	453.45	25.00
WINFISH 3506 25 KG BAG	35	312.03	12.48
WINFISH 3005 25 KG BAG	30	278.63	11.15
WINFISH 2505 25 KG BAG	25	264.8	10.59

Major inputs for Biofloc would include molasses, yeast, and pro-biotic components. (Pro-biotic foods were beneficial microorganisms or bacteria that remained active in the host's intestine in quantities large enough to alter the intestinal microbiota. This facilitates digestion, helps absorb nutrients, and strengthens the immune system. They could be recovered alive from fish excrement).

The materials to be used for the Biofloc system included wheat bran, molasses, sea salt, urea and ground food (see images of some of these ingredients in Exhibit 8). The molasses and yeast would be purchased from Agropec, a company in the state of Veracruz. The pro-biotic would be POND PLUS of Bayer®. Inputs such as wheat bran and sodium nitrite would be purchased from agricultural companies (Exhibit 7).

ii. Labor

Table 5 below shows the expected jobs from the project and their estimated costs per month:

Table 5
Number of jobs per gender and monthly cost
(In Mexican pesos)

Position	**Vacancy**	**Gender**	**Salary**	**Monthly total**
Administrative Manager	1	Male/Female	S20,646.00	$ 20,646.00
Technical Manager	1	Male/Female	$10,000.00	$10,000.00
Sales and Marketing	1	Male/Female	$ 8,000.00	$8,000.00
Technical Assistant	2	Male only	$5,000.00	$10,000.00
Support Staff	3	Male only	$1,800.00	$5,400.00
Caretaker	2	Male only	$3,800.00	$7,600.00
	10			$61,646.00

Exhibit 7 shows the projected labor costs as well as an itemization of the costs of services associated to the project.

i. Infrastructure and equipment

For equipment such as geomembrane ponds, blowers, oximeters, meshes and scales, among others there was contact with companies such as PMA in Sinaloa, Artífices Acuacultura S.A de C.V from Villahermosa, Tabasco, and DARE Alarmas y Electrónica S.A. DE C.V. from Monterrey, Nuevo León.

To carry out civil works, cleaning, electrical system, hydraulic system, greenhouse, ponds, delimitation of perimeter and health area, a contract with Constructora e Inmobiliaria Arte Maya del Norte SA de CV from Nuevo León was planned.

Production system proposed for the Eco-Farm

Fry could be purchased in Mexico in laboratories, aquaculture centers and aquaculture farms. Each of these sites offered different qualities and genetic lines, in which fry may or may not be given hormones and were generally sexed and masculinized to ensure final production. Hatcheries were thought to be a key link in the tilapia nurturing. With so much crossbreeding, feeding type, way of nurturing, hormones and all the biological action taken to obtain different genetic qualities in terms of size and mass had consequences. Sources mentioned that fry quality should not be lost sight of; it was necessary to obtain healthy fry. This was challenging since the quality of these centers as compared to certified producers was considered low.

The stage following purchasing or producing offspring on the farm was sowing and this required optimal infrastructure.

In the development stage, fish with weighing less than 5 grams were sown, with a density of 50 - 60 fish per cubic meter. These required a balanced, powdered feed with 45% protein, supplied at a rate of 10%-12% of biomass and distributed six to eight times a day, according to specifications in the products' technical specifications.

Pre-fattening was the stage dealing with fish weighing between 50 and 200 grams. Sowing density and percentage of water exchange in this stage would depend on the selected farming system, whether semi-intensive, intensive or super-intensive.

The fattening stage included developing the tilapia from 200 grams up to the harvest size or weight. At this stage, fish were fed balanced meals with 25%-32% protein content, depending on product type, water temperature, and farm management. It was suggested to supply food between 1% and 3% of biomass in 2 or 3 servings per day.

For all three stages above, it was thought that for fish to reach the proper weight and size it was necessary not only to determine sowing but also harvesting. Good management of cultivation activities meant improvements in follow-up. Besides contingencies could be prevented, use of resources could be optimized and good profitability could be obtained.

Harvest was the final stage of tilapia production and it took place when the fish had reached their desired commercial size, in principle, thought of as 500 grams in individual saucer size.

This last stage was divided into three sub-stages: pre-harvest, harvest, and post-harvest. Harvest was carried out with trawl nets (*chinchorros*), where fish were selected and separated into cages, later used for sale in the market.

This latest stage was seen as very important since fish was a perishable product, with very little conservation time. So, it had to be moved quickly under favorable conditions for conservation. (See images of pond management and final production in Exhibits 8 and 9.)

Some people thought that this part of the process could become problematic in Mexico since when producers lacked their own (or leased) fleet for distribution, they were forced to sell their product to intermediaries who made profits. In addition, intermediaries set the spot market price since there were no controlled prices. Sometimes the product had to be sold at very low prices to get it out quickly and avoid loss. Ideally, producers should market their products or have the cold infrastructure required for conservation. In Mexico and particularly in Chiapas very few aquaculture farms had such facilities.

It was also thought that more collaboration between farms, suppliers and customers was required to strengthen the value chain as this would help identify and define profitable markets for companies and greater benefits for all participants in the chain. In turn, this involved exploring alternatives based on market demands and offering new presentations of products to allow producers to give more value added to their products in the medium term.

On the other hand, different centers of technological development and teaching in the region were in charge of innovation and transfer of new technologies. This required better connection of producers with these centers to strengthen the progress of aquaculture in the country. At the same time, it was felt that better communication was required between producers, technology centers and the government, to maintain a continuous flow of knowledge and best practices throughout the production chain.

There was some history of health problems in the fishing cluster. There were specialized processing plants, with certifications of food safety and health whose designs included sanitary rugs, wind curtains; refrigerated work rooms, bathrooms for staff and loading area.

However, the lack or scarcity of industrialization plants nationwide was considered a constraint for many tilapia producers. Investments were high and there was not much capital in the sector where a good part of the production was in the hands of small and medium-size fish farmers.

Aguilera and Laínez thought that if the model implemented in eco-farms Michín were successful, it could be replicated in other places (hence the plural name). They thought that a closed system, in addition to the set of good practices included in the certification, as well as cost efficiency, could be extremely attractive for medium-sized producers in southern Mexico and northern Central America. Thus, they were not only thinking of their own growth but also of advising and giving technical advice to other producers for a fee.

Technical and economic factors to deal with

According to Acuícola Garza, sale prices could vary according to the area. In areas of more central access, such as Mexico City, the purchase price could reach up to \$ 32/kg, while in other faraway areas in the state of Oaxaca the price could even reach over \$ 90/kg. In the Yucatan Peninsula, according to the price established by the Tilapia Product System, the recommended farm gate price was \$ 42/kg. This price in 2014 was \$ 35/kg and in 2016 it rose to \$ 37/kg, and so on, gradually. Sale prices also depended on customers. Thus, a wholesale customer buying several tons of product could get prices from \$ 42- \$ 49/kg. On the other hand, retail farm gate prices were around \$ 55/kg.

Depending on the season, for example Easter, a slight increase could be expected due to higher seasonal demand. The prices also varied according to the value added to the product by the producer, either selling it eviscerated, without scales, and without gills. Price in these cases could be higher. Also, when product was delivered in restaurants or stores prices could be up to \$ 68/kg.

Financial feasibility of the project

As part of the process to request financial support from Mexican agencies supporting small and medium-sized producers, Mr. Aguilera had asked Dr. Adriana Ferreira Da Silva and her management team to prepare a financial feasibility study. Dr. Ferreira was the general manager of Acuícola Garza. The figures showed that the project would be profitable. According to the study, the reported internal rate of return (IRR) was 17%, the benefit-cost ratio was 1.23 and ROA (return on assets) amounted to 51%.

When Félix Laínez saw the study and the results he told Mauricio: "I am impressed by the support SAGARPA gives to producers in Mexico, Dr. Ferreira's team has done a good job". MBA Sagrario Padilla, administrative manager of Acuícola Garza, also helped create these estimates. "I would like to check these estimates and identify critical variables in this business to review cash flows again," she said. "I think that once we have this reviewed and revised if needed, we would conduct risk analysis for a more complete vision of the impact of risk involved in the project."

Dr. Laínez told Mr. Aguilera: "I have been working with the figures and I believe the variables and parameters to take into consideration are: the time to analyze the project's economic life would be 10 years, the proposed capital structure would be 80% debt (including working capital) and 20% equity. Production would grow 5.8% a year (based on the annual growth rate of inland aquaculture). In the first year, 36.1 tons of tilapia would be produced and sold. The growth rate of the geometric gradient in year 10 would be the same as the annual rate of increase in production. The interest rate on debt would be 8.25% (Central Bank of Mexico as of March 2019). Prices would be $ 50 / kg (average local market price). These prices would then increase 3% a year, reaching $ 55 / kg in year 5. From then on, the price would remain level until year 10. Tax rate would be 30% and fixed and variable costs would increase annually at the inflation rate (forecast to June 3, 2019, Trading Economics, Instituto de Estadística y Geografía –INEGI) as seen in Exhibit 10.

Decisions to make

Although there were still several questions the business model desired was quite clear. Mauricio Aguilera and Félix Laínez wondered what the value proposition for the company should be. What was the feasible farm size to reach before moving to other locations? How would they overcome the financing challenges they were facing now that August 2019, the month when the first harvest may begin, was close? Were they leaving something outside?

With these questions in mind, Mauricio and his partner Félix Laínez checked the forecasts for the first production. At the end of the meeting and following a suggestion from Mr. Laínez, they made a table of activities, lengths, and precedents (see Exhibit 1) to have a better idea of when the operational phase of the project would start, since August looked so close. This information had been checked with Nancy Pérez Hernández, the newly hired biologist of the Eco-Granjas Michín project. Ms. Pérez had just completed practical training in Acuícula Garza in the state of Yucatán.

Exhibit 1

Eco-Granjas Michín Activities, Lengths (Three Estimates), Precedents y Percentage of Completion for Tasks/Activities

	Description of activity	*Length (months)*				
		Optimistic	Most likely	Precedence	Pessimistic	% Progress
1.	Land cleaning	**N.A.**	**3**	**N.A.**	**Any**	**100%**
2.	Cleaning and deepening of wells.	**N.A.**	**0.5**	**N.A.**	**Any**	**100%**
3.	Obtaining bank financing	**2**	**3**		**Any**	**0%**
4.	Construction of biofloc ponds.	**N.A.**	**3**	**N.A.**	**1**	**100%**
5.	Pond construction	**N.A.**	**3**	**N.A.**	**1.3**	**50%**
6.	Acquisition of main pumping equipment.	**1**	**2**	**3**	**1.3**	**0%**
7.	Installation of main pumping equipment	**2**	**3**	**6**	**2.6**	**20%**
8.	Acquisition of sediment evacuation pumps.	**2**	**3**	**6**	**2.6**	**0%**
9.	Installation of sediment evacuation pumps.	**0.3**	**0.5**	**1**	**3.12**	**0%**
10.	Acquisition of aerators	**0.3**	**0.5**	**1**	**3**	**0%**
11.	Installation of aerators	**0.25**	**0.5**	**1**	**10**	**0%**
12.	Construction of pumping and aeration cabins	**0.5**	**0.75**	**1**	**1.3**	**0%**
13.	Acquisition of solar panels	**2**	**3**	**4**	**1.3**	**0%**
14.	Installation of solar panels	**1**	**1.5**	**2**	**13**	**30%**
15.	Introduction to electric power	**3**	**4**	**6**	**3**	**30%**
16.	Office and lab construction	**0.5**	**0.75**	**1**	**3**	**0%**
17.	Acquisition and installation of lab equipment	**1**	**1.5**	**2**	**3.16**	**70%**
18.	Construction of food and supplies warehouses (biofloc fertilization)	**1**	**2**	**2.5**	**3**	**0%**
19.	Acquisition of equipment and tools for tank maintenance and operation	**1**	**1.5**	**2**	**3**	**10%**
20.	Installation of mesh fence	**0.5**	**0.75**	**1**	**3**	**0%**
21.	Acquisition and installation of predatory bird mesh and shade mesh	**1**	**1.5**	**2**	**3**	**0%**
22.	Construction and equipment of diversion area.	**0.75**	**1**	**1.5**	**3**	**0%**

23.	Recruitment of complementary personnel.	**0.5**	**1**	**1.5**	**3**	**0%**
24.	Staff training	**0.3**	**0.5**	**0.75**	**23**	**40%**
25.	Acquisition of emergency plant	**1**	**1.5**	**2**	**14.15**	**0%**
26.	Acquisition of office supplies	**0.75**	**1**	**1.5**	**3**	**0%**
27.	First production (harvest)	**4**	**6**	**7**	**29.30.24.28**	**0%**
28.	System test	**0.25**	**0.3**	**0.5**	**24.25.20.21.22.23**	**0%**
29.	Acquisition of fry	**0.75**	**1**	**1.5**	**28**	**0%**
30.	Purchase of supplies	**0.75**	**1**	**1.5**	**3.18**	**0%**
31.	Cleaning and disinfection of ponds	**0.1**	**0.13**	**0.17**	**28**	**0%**
32.	Initiation and fertilization to generate biofloc	**0.3**	**0.4**	**0.5**	**31**	**0%**
33.	Sowing stress test	**0.03**	**0.07**	**0.1**	**29**	**0%**

Exhibit 2

Fixed and Deferred Investment – Year 0; Working Capital –Year 1

Item	Description	Quantity	Unit	$ Unit	Total
Ponds					
Fattening tank	12 m. wide X 1.2 m deep, galvanized steel and geomembrane	10	Piece	$ 50,000.00	$ 500,000.00
Pre-breeding tank	7 m. wide X 1.2 m deep, galvanized steel and geomembrane	2	Piece	$ 15,000.00	$ 30,000.00
Acclimatization tanks	1,000 liters for post-larva acclimatization	2	Piece	$ 5,000.00	$ 10,000.00
Floc storing pond	20X20X1.2 floc store	1	Construc-tion	$ 130,000.00	$ 130,000.00
1 mm HOPE geomembrane	Floc warehouse coating	700	M2	$ 115.00	$ 80,500.00
3HP blower	Three-phase FPZ	7	Piece	$ 28,670.00	$ 200,690.00
2 HP Splash aerator (KASCO MARINE)	Splash aerator	5	Piece	$ 27,000.00	$ 135,000.00
1 HP Paddle aerator	1 HP aerator	4	Piece	$ 18,000.00	$ 72,000.00
7.5 H.P. centrifugal pump	Well water pumping	2	Piece	$ 25,000.00	$ 50,000.00
1/4 H.P. centrifugal pump to clarify	Water movement	6	Piece	$ 1,500.00	$ 9,000.00
Diffuser hose	Hose roll	4	Roll	$ 7,150.00	$ 28,600.00
21KVA, 240/440 V three-phase diesel generator	Backup power plant	1	Piece	$ 240,000.00	$ 240,000.00
Oximeter	Oxygen, temperature	2	Piece	$ 30,000.00	$ 60,000.00
Water-quality kits	Ammonium, nitrite and nitrate	24	Piece	$ 1,500.00	$ 36,000.00

¼ and ½ sweep nets	¼ and ½ sampling sweep nets	4	Piece	$ 2,500.00	$ 10,000.00
Imhoff cone	Sedimentation cone to measure biofloc	3	Piece	$ 1,200.00	$ 3,600.00
Digital scale – 0.1g x 600 g	Biometric scale	2	Piece	$ 12,738.78	$ 25477.56
2 KG. OHAUS scale	Scale to weigh foodstuffs	2	Piece	$ 8,234.40	$ 16,468.80
150 KG. scale	Harvest scale	1	Piece	$ 9,640.64	$ 9,640.64
60 Kg. plastic baskets	Harvest basket	20	Piece	$ 450.00	$ 9,000.00
Harvest trawling net	Fish harvest net	1	Piece	$ 20,000.00	$ 20,000.00
Biofloc clarifier	Biofloc clarifiers	6	Piece	$ 16,000.00	$ 96,000.00
Electronic microscope	To monitor floc	1	Piece	$ 18,700.00	$ 18,700.00
Stereoscope	To monitor floc	1	Piece	$ 15,973.00	$ 15,973.00
65% shade mesh	Shade mesh	1582	M2	$ 25.00	$ 39,550.00
Computer	Office equipment	1	Piece	S15, 000.00	S15, 000.00
Printer	Office equipment	1	Piece	$ 4,000.00	$ 4,000.00
Chairs	Office equipment	4	Piece	$ 3,200.00	$ 12,800.00
Desk	Office equipment	3	Piece	$ 4,000.00	$ 12,000.00
Board meeting room furniture (table & chairs)	Office equipment	1	Chairs and table set	$ 25,000.00	$ 25,000.00
				Subtotal	$ 1915,000.00
Construction					
Installation	Site preparation, construction and installation of the farm. Includes office area, guard house, engine house, perimeter, food shed, blower booths, sanitary mats, drainage installation, ditches, embankments, light poles, transformer, electrification of production areas, office, equipment pumping, well drilling and solar panels.	1	Work	$ 2085,000.00	$ 2085,000.00

Permit payments and project development				$ 4,000,000.00
Item	**Quantity**	**Unit**	**$ Unit**	**Total**
MIA making	1	Service	$ 80,000.00	$ 80,000.00
MIA registration fee	1	Payment	$ 32,000.00	$ 32,000.00
CONAGUA payment	1	Service	$ 12,769.00	$ 12,769.00
Training for biofloc cultivation	1	Service	$ 50,000.00	$ 50,000.00
Technical assistance	1	Service	$ 100,000.00	$ 100,000.00
Development of executive project	1	Service	$ 80,000.00	$ 80,000.00
Implementation	1	Service	$ 200,000.00	$ 200,000.00
Total				**$ 554,769.00**
WORKING CAPITAL				
Working Capital				$ 731,340.22
			SUBTOTAL	***$ 731,340.22***
			Project total	$ 5286,109.22

Exhibit 3

Fixed Assets, Depreciation, and Residual Value of Assets

DEPRECIATION COSTS

FIXED ASSETS	ORIGINAL VALUE	ANNUAL RATE	YEARS	ANNUAL DEPRE-CIATION	SALVAGE VALUE
Fattening tank	$ 500,000.00	5%	20	$ 25,000.00	$ 375,000.00
Acclimatization tanks	$ 10,000.00	5%	20	$ 500.00	$ 7,500.00
Floc Storage Pond	$ 130,000.00	5%	20	$ 6,500.00	$ 97,500.00
1 mm HOPE geomembrane	$ 80,500.00	5%	20	$ 4,025.00	$ 60, 375.00
3 HP Blower	$ 200,690.00	6%	17	$ 11,805.2B	$ 141,663.53
Diffuser hose	$ 28,600.00	10%	10	$ 2,860.00	$ 14, 300.00
21KVA, 240/440 V three-phase diesel generator	$ 240,000.00	5%	20	$ 12,000.00	$ 180,00
Oximeter	$ 60,000.00	7%	15	$ 4,000.00	$ 40,000.00
Water-quality kits	$ 36,000.00	7%	15	$ 2,400.00	$ 24,000.00
¼ and ½ sweep nets	$ 10,000.00	10%	10	$ 1, 000.00	$ 5,000.00
Imhoff cone	$ 3, 600.00	7%	15	$ 240.00	$ 2,400.00
Digital Scale 0.1g x 600g	$ 25,477.56	10%	10	$ 2,547.76	$ 12,738.78
2 KG OHAUS Scale	$ 16,468.80	10%	10	$ 1,646.88	$ 8, 234.40
150 KG Scale	$ 9,640.64	10%	10	$ 964.06	$ 4,820.32
60 kg plastic baskets	$ 9,000.00		8	$ 1,125. 00	$ 3,375.00
Harvest trawling net	$ 20,000.00	10%	10	$ 2,000.00	$ 10,000.00
Biofloc clarifier	$ 96,000.00	5%	20	$ 4,800.00	$ 72,000.00
Electronic microscope	$ 18,700.00	5%	20	$ 935.00	$ 14,025.00
65% shade mesh	$ 39,550.00	7%	15	$ 2,636.67	$ 26,366.67
TOTAL	**$1534,227.00**			**$ 86,985.66**	**$ 1099,298.70**

Exhibit 4

Project Production Costs – Five-year Forecast

TOTAL PRODUCTION COSTS FORECAST

FIXED COSTS	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
UTILITIES	$ 149.630.31	$ 157.111.82	$ 164.967.41	$ 173.215.79	$ 181.876.57
LABOR	$ 739.752.00	$ 739.752.00	$ 776.739.60	$ 815.576.58	$ 856.355.41
TOTAL	**$ 889.382.31**	**$ 896.863.82**	**$ 941.707.01**	**$ 988.792.37**	**$ 1038.231.98**
VARIABLE COSTS	**YEAR 1**	**YEAR 2**	**YEAR 3**	**YEAR 4**	**YEAR 5**
Fry	$ 104.500.00	$ 109.725.00	$ 115.211.25	$ 120.981.81	$ 127.020.40
Foodstuffs	$ 491.057.53	$ 621.089.05	$ 652.143.50	$ 684.750.68	$ 718.988.21
Inputs (fertilization)	$ 394.591.94	$ 414.321.55	$ 435.037.63	$ 456.789.51	$ 479.628.98
TOTAL	**$ 990.149.48**	**$ 1145.135.60**	**$ 1202.392.38**	**$ 1262.512.00**	**$ 1325.617.60**
	YEAR 1	**YEAR2**	**YEAR 3**	**YEAR 4**	**YEAR 5**
FIXED COSTS	**$ 889.382.31**	**$ 896.863.82**	**$ 941.707.01**	**$ 988.792.37**	**$ 1038.231.98**
VARIABLE COSTS	**$ 990.149.48**	**$ 1145.135.60**	**$ 1202.392.38**	**$ 1262.512.00**	**$ 1325.637.60**
TOTAL COSTS	**$ 1879.531.79**	**$ 2041.999.42**	**$ 2144.099.39**	**$ 2251.304.36**	**$ 2363.869.58**

Exhibit 5

Materials Used for the Biofloc System

Exhibit 6
Cost of Fry and Growth of Litters

Fry purchase				
Item	**Quantity**	**Unit**	**Unit cost**	**Amount**
Fry/lot	17417	Fry	$ 1.00	$ 17.416.67
Lot/year	6	Lot	$ 17.416.67	$ 104.500.00
TOTAL				**$ 104.500.00**

(6 lots required for a year)

Months

Stage	Unit $	1	2	3	4	5	6	7	8	9	10	11	12	Total number of fish
Sowing		17.417	17.417		17.417		17.417		17.417		17.417			104.500
Cost	$ 1.00	$ 17.416.67	$ 17.416.67		$ 17.416.67		$ 17.416.67		$ 17.416.67		$ 17.416.67			$ 104.500

Expected mortality rate summary

Stage	% survival	Number of fish	
Purchase		17.417	
Sowing	90%	17.417	Day 1
Pre-breeding	95%	16.546	Month 1
Breeding	98%	16.215	Month 2
Breeding	98%	15.891	Month 3
Fattening	99%	15.795	Month 4
Fattening	99%	15.685	Month 5
Fattening	99%	15.575	Month 6

Number of fish – Year 1	Months												
Stage	1	2	3	4	5	6	7	8	9	10	11	12	Total number of fish
Pre-breeding	17.417		17.417		17.417		17.417		17.417		17.417		104.500
Breeding		16.215		17.068	-	17.068	-	17.068	-	17.068	-	17.068	101.557
Breeding			15.891	-	19.966		16.966	-	16.966	-	16.966	-	83.754
Fattening				15.795	-	16.847	-	16.847	-	16.847	-	16.847	83.184
Fattening					15.685	-	16.729	-	16.729	-	16.729	-	65.872
Fattening						15.575		15.575		15.575		15.575	
Total	17.417	16.215	33.307	32.864	50.067	33.915	51.112	33.915	51.112	33.915	51.112	33.915	**438.867**

Number of fish – Year 2-5	Months												
Stage	1	2	3	4	5	6	7	8	9	10	11	12	Total number of fish
Pre-breeding	17.417		17.417	-	17.417	-	17.417	-	17.417		17.417	-	104.500
Breeding	-	16.546	-	16.546	-	16.546	-	17.068	-	17.068	-	17.068	101.843
Breeding	16.215	-	16.215	-	16.215	-	16.966	-	16.966	-	16.966	-	99.543
Fattening	15.685	15.891	-	15.891	-	15.891	-	16.847	-	16.847	-	16.847	113.898
Fattening	15.685		15.795	-	15.795	-	15.795	-	16.729	-	16.729	-	96.529
Fattening		15.575		15.575		15.575		15.575		15.575		15.575	93.449
Total	65.001	32.436	49.427	48.011	49.427	48.011	59.178	49.490	51.112	49.490	51.112	49.490	

FOOD CONSUMPTION ANALYSIS													
Stage	**Growing Week**	**Growing days**	**Fish weight (grams)**	**Food type/ PROTEIN**	**% FEEDING RATE**	**% fish for lot**	**Biomass per lot (Kg.)**	**Food per lot (Kg/DAY)**	**Food per lot (Kg/WEEK)**	**Cost of food (Kg.)**	**Weekly cost of food per lot**	**Monthly cost of food per lot**	**Total cost of food consumed per lot**
Pre-breeding – Month 1	1	7	1	40%	7.0	46.000	46.00	3.220	22.54	$25.0	$563.50	$8.533.00	$162.986.35
	2	7	3	40%	7.0	46.000	138.00	9.660	67.62	$25.0	$1.690.50		
	3	7	5	40%	6.0	46.000	230.00	13.800	96.60	$25.0	$2.415.00		
	4	7	8	40%	6.0	46.000	368.00	22.080	154.56	$25.0	$3.864.00		
Breeding – Month 2	5	7	10	35%	5.0	16.215	162.15	8.107	56.75	$25.0	$1.418.81	$6.248.72	
	6	7	13	35%	5.0	16.215	210.79	10.540	73.38	$25.0	$1.844.45		
	7	7	22	35%	4.0	16.215	356.73	14.269	99.88	$11.1	$1.113.23		
	8	7	37	35%	4.0	16.215	599.95	13.998	167.99	$11.1	$1.872.24		
Breeding – Month 3	9	7	46	30%	3.5	15.891	730.97	25.584	179.09	$11.1	$1.995.96	$15.403.63	
	10	7	69	30%	3.5	15.891	1.096.45	38.376	268.63	$11.1	$2.993.95		
	11		100	30%	3.5	15.891	1.589.06	55.617	389.32	$11.1	$4.339.05		
	12	7	140	30%	3.5	15.891	2.224.69	77.864	545.05	$11.1	$6.074.67		
Fattening – Month 4	13	7	170	25%	3.0	15.795	2.685.20	80.556	563.89	$10.6	$5.972.74	$32.031.09	
	14	7	210	25%	3.0	15.795	3.317.01	99.510	696.57	$10.6	$7.378.09		
	15	7	250	25%	3.0	15.795	3.948.82	118.465	829.25	$10.6	$8.783.44		
	16	7	280	25%	3.0	15.891	4.449.37	133.481	934.37	$10.6	$9.896.83		
Fattening – Month 5	17	7	300	25%	2.5	15.685	4.701.41	117.635	823.45	$10.6	$8.721.95	$41.298.40	
	18	7	335	25%	2.5	15.685	5.254.38	131.359	919.52	$10.6	$9.739.51		
	19	7	370	25%	2.5	15.795	5.844.25	146.106	1022.74	$10.6	$10.832.90		
	20	7	410	25%	2.5	15.795	6.476.06	161.902	1133.31	$10.6	$12.004.03		
Fattening – Month 6	21	7	450	25%	2.5	15.575	7.008.71	175.218	1226.52	$10.6	$12.991.35	$59.471.50	
	22	7	490	25%	2.5	15.575	7.631.71	190.793	1335.55	$10.6	$14.146.13		
	23	7	540	25%	2.5	15.575	8.410.45	210.261	1471.83	$10.6	$15.589.62		
	20	7	580	25%	2.5	15.575	9.033.45	225.836	1580.85	$10.6	$16.744.40		

COST TABLE			
NAME	% PROTEIN	PRICE PER BAG	PRICE PER KG
WINFISH 4010 25 KG BAG	40	453.45	25.00
WINFISH 3506 25 KG BAG	35	312.03	12.48
WINFISH 3005 25 KG BAG	30	278.63	11.15
WINFISH 2505 25 KG BAG	25	264.8	10.59

SUMMARY	$ (M.N.)
1 MONTH	$ 8.533.00
2 MONTHS	$ 6.248.72
3 MONTHS	$ 15.403.63
4 MONTHS	$ 32.031.09
5 MONTHS	$ 41.298.40
6 MONTHS	$ 59.471.50
TOTAL/LOT	$ 162.986.35

Food – Year 1	**Months**											
Stage	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Pre-breeding	$8.533		$8.533		$8.533		$8.533		$8.533		$8.533	
Breeding		$6.249		$6.249		$6.249		$6.249		$6.249		$6.249
Breeding			$15.404		$15.404		$15.404		$15.404		$15.404	
Fattening				$32.031		$32.031		$32.031		$32.031		$32.031
Fattening					$41.298		$41.298		$41.298		$41.298	
Monthly cost of food	$8.533	$6.249	$23.937	$38.280	$65.235	$38.280	$65.235	$38.280	$65.235	$38.280	$65.235	$38.280

Food – Years 2-5	**Months**											
Stage	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Pre-breeding	$8.533	$0	$8.533	$0	$8.533	$0	$8.533	$0	$8.533	$0	$8.533	$0
Breeding	$0	$6.249	$0	$6.249	$0	$6.249	$0	$6.249	$0	$6.249	$0	$6.249
Breeding	$15.404	$0	$15.404	$0	$15.404	$0	$15.404	$0	$15.404	$0	$15.404	$0
Fattening	$0	$32.031	$0	$32.031	$0	$32.031	$0	$32.031	$0	$32.031	$0	$32.031
Fattening	$41.298	$0	$41.298	$0	$41.298	$0	$41.298	$0	$41.298	$0	$41.298	$0
Monthly cost of food	$65.235	$38.280	$65.235	$38.280	$65.235	$38.280	$65.235	$38.280	$65.235	$38.280	$65.235	$38.280

Biomass – Year 1 (Kg.)	**Months**												
Stage	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total biomass (g)**
Sowing	46		46		46		46		46		46		276
Pre-breeding	368		368		368		368		368		368		2.208
Breeding		600		600		600		600		600		600	3.600
Breeding			2.225		2.225		2.225		2.225		2.225		11.123
Fattening				4.449		4.449		4.449		4.449		4.449	22.247
Fattening					6.476		6.476		6.476		6.476		
Fattening						9.033		9.033		9.033		9.033	36.134
Monthly Total	368	600	2.593	5.049	9.069	14.083	9.069	14.083	9.069	14.083	9.069	14.083	**75.312**
Total harvest (Kg.)						**9.033.45**	-	**9.033.45**	-	**9.033.45**	-	**9.033.45**	**36.13**

Biomass – Year 2-5 (Kg.)	**Months**												
Stage	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total biomass (g)**
Sowing	46	-	46	-	46	-	46	-	46	46	46	-	322
Pre-breeding	368	-	368	-	368	-	368	-	368	368	368	-	2.576
Breeding	-	600		600	-	600	-	600	-	600	-	600	1.600
Breeding	2.225	-	2.225	-	2.225	-	2.225	-	2.225		2.225	-	13.348
Fattening	-	4.449	-	4.449	-	4.449	-	4.449	-	4.449	-	4.449	26.696
Fattening	6.476	-	6.476	-	6.476		6.476		6.476		6.476		38.856
Fattening		9.033		9.033		9.033		9.033		9.033		9.033	
Monthly Total	9.069	14.083	9.069	5.049	9.069	14.083	9.069	14.083	9.069	5.417	9.069	14.083	**85.076**
Total harvest (Kg.)		**9.033.45**		**9.033.45**		**9.033.45**	-	**9.033.45**	-	**9.033.45**	-	**9.033.45**	**54.200.70**

Exhibit 7

Itemization of Input Costs, Water, Utilities, and Salaries

Inputs required – Year 1		**Months**											
Item	**Unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Sodium nitrite	Kg.	4		4				4		4			
Probiotic	Kg.	5		5		5		5		5		5	
Vitamin C	Kg.	1		1				1		1		1	
Molasses and yeast	Kg.	72	72	72	72	72	72	72	72	72	72	72	72
Lime	Bag	4		4		4	4	4		4		4	4
Chlorine	Gallon	4	4	4	4	4	4	4	4	4	4	4	4
Hydrogen peroxide	Gallon	15		15		15		15		15		15	
Salt	Kg.												
Reagents	Package	6	6	9	9	6	6	6	6	9	8	6	9

Inputs cost – Year 1		**Months**												
Item	**Unit price**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**TOTAL**
Sodium nitrite	$80.00	$320.00	$0.00	$320.00	$0.00	$0.00	$0.00	$320.00	$0.00	$320.00	$0.00	$0.00	$0.00	$1.280.00
Probiotic	$130.00	$650.00	$0.00	$650.00	$0.00	$650.00	$0.00	$650.00	$0.00	$650.00	$0.00	$650.00	$0.00	$3.900.00
Vitamin C	$6.50	$6.50	$0.00	$6.50	$0.00	$0.00	$0.00	$6.50	$0.00	$6.50	$0.00	$6.50	$0.00	$32.50
Molasses	$70.00	$5.073.41	$5.073.41	$5.073.41	$5.073.41	$5.073.41	$5.073.41	$5.073.41	$5.073.41	$5.073.41	$5.073.41	$5.073.41	$5.073.41	$60.880.95
Lime	$50.00	$200.00	$0.00	$200.00	$0.00	$200	$200	$200.00	$0.00	$0.00	$0.00	$200.00	$200.00	$1.600.00
Chlorine	$100.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$4.800.00
Hydrogen peroxide	$120.00	$1.800.00	$0.00	$1.800.00	$0.00	$1.800.00	$0.00	$1.800.00	$0.00	$1.800.00	$0.00	$1.800.00	$0.00	$10.800.00
Reagents	$3.619.75	$21.718.50	$21.718.50	$32.577.75	$32.577.75	$21.718.50	$21.718.50	$21.718.50	$21.718.50	$32.577.75	$28.958.00	$21.718.50	$32.577.75	$311.298.50
Total		$30.168.41	$27.191.91	$41.027.66	$38.051.16	$29.841.91	$27.391.91	$30.168.41	$27.191.91	$41.027.66	$34.431.41	$29.848.41	$38.251.16	$394.591.95

Nitrite reagents YSI	1	Kit	$ 642.42	$ 642.42
Nitrate reagents Ysi	1	Kit	$ 1.054.03	$ 1.054.03
Ammonium reagents Ysi	2	Kit	$ 961.65	$ 1.923.30
				$ 3.619.75

Water consumption calculation

Area	Tank volume	% replenishment	Monthly replenishment
Pre-breeding	92.4	4.62	18.5
Breeding	542.9	27.14	108.6
Fattening	814.3	40.72	162.9

Water consumption analysis

Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Test filling (m3)	1449.5												
Pre-breeding	92.4	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	
Breeding		542.9	108.6	108.6	108.6	108.6	108.6	108.6	108.6	108.6	108.6	108.6	
Fattening			814.3	162.9	162.9	162.9	162.9	162.9	162.9	162.9	162.9	162.9	
Pre-breeding washing*		46.2		46.2		46.2		46.2		46.2		46.2	
Breeding washing*				271.4		271.4		271.4		271.4		271.4	
Fattening washing*					407.2		407.2		407.2		407.2		
Total requirement	1541.9	607.5	941.4	607.5	697.1	607.5	697.1	607.5	697.1	607.5	697.1	607.5	8.917
Total discharger water*	0.0	46.2	0.0	317.6	407.2	317.6	407.2	317.6	407.2	317.6	407.2	317.6	3.263

Power Monthly Data

Item	HP	Consumption-Kw	Price – Kw/hour	Hours/month*	Amount/month (with full use)	
Power – Production floor						*Total production floor cost*
Blowers (production)	50	37.29	$0.80	720	$21.476.16	
Power – Office area		1	$0.80	360	$288.00	
				Total	**$21.764.16**	

***1 HP = 07457 KW*

* *Round-the-clock operation in the production floor; 12 hours per day for the office area.*

Services	**Months**											
Item	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Power- production floor	$21.476.16	$21.476.16	$21.476.16	$21.476.16	$21.476.16	$21.476.16	$21.476.16	$21.476.16	$21.476.16	$21.476.16	$21.476.16	$21.476.16
Power – office area	$288.00	$288.00	$288.00	$288.00	$288.00	$288.00	$288.00	$288.00	$288.00	$288.00	$288.00	$288.00
Total	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16

SERVICES	Month												
Item	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**YEAR TOTAL**
Power	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$21.764.16	$261.169.92
Internet	$600.00	$600.00	$600.00	$600.00	$600.00	$600.00	$600.00	$600.00	$600.00	$600.00	$600.00	$600.00	$7.200.00
Housekeeping	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$400.00	$4.800.00
Accountant	$2.000.00	$2.000.00	$2.000.00	$2.000.00	$2.000.00	$2.000.00	$2.000.00	$2.000.00	$2.000.00	$2.000.00	$2.000.00	$2.000.00	$24.000.00
Drinking water	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$2.400.00
Garbage collection	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$240.00
Staff	$500.00	$500.00	$500.00	$500.00	$500.00	$500.00	$500.00	$500.00	$500.00	$500.00	$500.00	$500.00	$6.000.00
TOTAL	$25.484.16	$25.484.16	$25.484.16	$25.484.16	$25.484.16	$25.484.16	$25.484.16	$25.484.16	$25.484.16	$25.484.16	$25.484.16	$25.484.16	**$305.809.92**

Salary

Position	Vacancy	Gender	Salary	Monthly total
Administrative Manager	1	Indifferent	$20.646.00	$20.646.00
Technical Manager	1	Indifferent	$10.000.00	$10.000.00
Sales and Marketing	1	Indifferent	$8.000.00	$8.000.00
Technical Assistant	2	Masculine	$5.000.00	$10.000.00
Support Staff	3	Masculine	$1.800.00	$5.400.00
Caretaker	2	Masculine	$3.800.00	$7.600.00
				$61.646.00

Cost of salaries

	Month												
Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**YEAR TOTAL**
Administrative Manager	$20.646.00	$20.646.00	$20.646.00	$20.646.00	$20.646.00	$20.646.00	$20.646.00	$20.646.00	$20.646.00	$20.646.00	$20.646.00	$20.646.00	$247.752.00
Technical Manager	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$120.000.00
Sales and Marketing	$8.000.00	$8.000.00	$8.000.00	$8.000.00	$8.000.00	$8.000.00	$8.000.00	$8.000.00	$8.000.00	$8.000.00	$8.000.00	$8.000.00	$86.000.00
Technical Assistant	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$10.000.00	$120.000.00
Support Staff	$5.400.00	$5.400.00	$5.400.00	$5.400.00	$5.400.00	$5.400.00	$5.400.00	$5.400.00	$5.400.00	$5.400.00	$5.400.00	$5.400.00	$64.800.00
Caretaker	$7.600.00	$7.600.00	$7.600.00	$7.600.00	$7.600.00	$7.600.00	$7.600.00	$7.600.00	$7.600.00	$7.600.00	$7.600.00	$7.600.00	$91.200.00
Monthly total	$61.646.00	$61.646.00	$61.646.00	$61.646.00	$61.646.00	$61.646.00	$61.646.00	$61.646.00	$61.646.00	$61.646.00	$61.646.00	$61.646.00	**$739.752.00**

Exhibit 8

Water quality control and Biofloc levels

Exhibit 9

ECO-GRANJAS
MICHIN

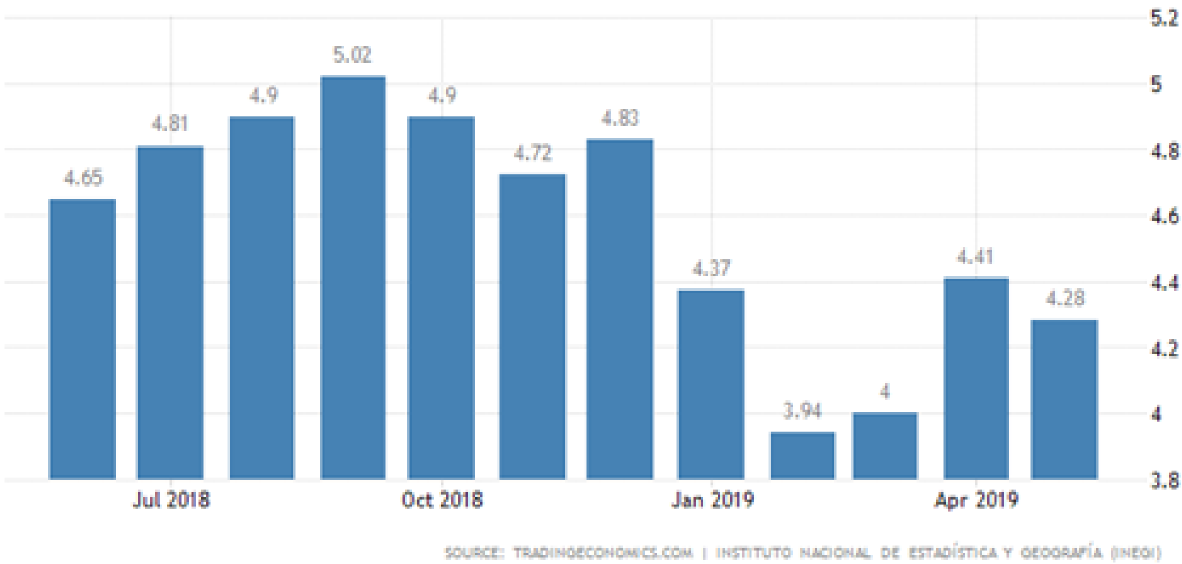
Tilapia harvested in tanks

Exhibit 10

Mexico - Projected Inflation

June 2018-April 2019

Mexico – Projected Annual Inflation Rate



Eco-Granjas “Michin S.A. de CV”
Teaching Note

Synopsis

In October 2018 Engineer Mauricio Aguilera Contreras was reviewing the financial projections of a tilapia production project located just 20 minutes away from the airport in Tuxtla Gutiérrez, the capital city of the state of Chiapas in Mexico. Mauricio was surprised to see the results originally provided by Acuícola Garza, a company operating in Yucatán, making the project look profitable. Acuícola Garza had a solid scientific basis in tilapia production, and highly qualified technical staff that had begun to provide technical advice to Eco Farms Michin.

Mauricio wanted an innovative, well-managed, eco-efficient project. For this end, he was installing solar panels to have a source of clean, 100% renewable energy. In addition, he was installing a biofloc system that would not only decrease feeding costs (which were significant in aquaculture), but also to improve the fish nutritional and health conditions. Once the business model was validated, he intended to replicate it in other locations or offer advice to other investors wishing to have a sustainable, innocuous model.

Félix Laínez checked the financial figures he had received. After making correlations and adjustments he was surprised to see that the project made much sense if some assumptions were changed. For example, according to him, the project was not profitable with conventional energy sources; however, it became attractive by cutting down these costs through photovoltaic solar energy.

Introduction

This case study was written to be used in the Sustainability Management or Sustainable Development course for INCAE’s MBA and EMBA Programs. It can also be used in entrepreneurship and Finance 2 courses as well as in executive education seminars on agro-industrial strategy. The case has enough information to be developed in two parts so that the instructor can decide which of them to stress. In principle, a session is recommended for each part, although it could be handled in a single session depending on the topics covered in previous sessions of the course and the emphasis the instructor wants to give to each part.

Teaching Objectives

1. Understand the conceptual framework of aquaculture activity: reproduction, feeding, product processing, market and environment.

2. Use the understanding of this conceptual interaction to evaluate this aquaculture sustainability project through renewable resources and use of clean energies. Also, analyze what the company's final value proposal should be.

3. Identify Eco-farms "Michín" business model using the Osterwalder canvas; also identify the different participants in the value chain (Porter) and the agro-industrial system (Fenton and Artavia). What are its interests, objectives, and so on?

4. Create awareness of the complementarity offered by a strategic analysis and a financial analysis to make managerial decisions and changes in improvement projects.

Analysis

The plan proposed below assumes that this case study will be developed in two 80-minute sessions. The instructor, however, may decide to teach the case in a single session giving more emphasis to one of its parts.

The authors suggest to open the class by discussing the most important points in the aquaculture industry so that students can understand the current landscape of this industry, its processes and development, until its final products. Clearly, students must understand reproduction, fattening, type of food, expenses required in this business, difficulties and challenges, and commercial scenario. Next, students will be able to analyze in depth what is required to develop this kind of project, what could be improved, and analyze improvement options so that they may be able to make decisions about what the value proposal should be for this type of company.

Part I: Fundamentals of the aquaculture industry (One 80-minute session)

This section is intended to help readers understand the elements making up the aquaculture industry within a conceptual framework allowing them to visualize how to develop this business, forms of reproduction, fish farming, feeding, product processing, final packaging, sanitary elements and legal regulations. This case study has enough information on the elements of the strategic management framework; the strategic resources (skills and capacities required), the international market and an explanation of the project to be implemented using clean energy can be identified. The instructor should guide the session so that at the end of this first section students have a broad knowledge about the conceptual framework of the aquaculture industry. This way, students will be able to analyze potential weaknesses, development of new strategies and process improvement in the aquaculture industry.

The agro-industrial system analytical framework is very helpful in this first section of case analysis and discussion.

Part II: Evaluation of the aquaculture project with clean energies. (One 80-minute session)

The first part of this section comprises a description of the project's proposed strategy by using the Osterwalder canvas. The analysis ends with the project's cost and income structure.

The second stage of the discussion aims to understand how the elements analyzed in Part I interact. Based on the information given in the case about the project, understand the convenience of investing in the Eco Farms Michin business using clean energy and minimizing waste.

Consequently, this part is built on qualitative elements of Part I. Analytical elements of renewable energies are added to determine the convenience of investing in this project and how to develop this industry with 100% of clean, renewable energies in order to add value to the product. The latter must be achieved through improvements not only in nutritional conditions but also in the measures of product health, in addition to reducing production costs in the medium and long term.

Since sustainability management and sustainable development are advanced courses in sustainability, students are expected to know the sustainable industry concept. The goal is not for them to learn it this course, but to improve their understanding of how this industry can be used with other qualitative elements to make strategic business decisions and implement sustainable projects. This section raises much more directly the decision about which businesses to invest or disinvest in order to attain the desired goals, in the light of qualitative analysis regarding the use of clean, 100% renewable energy sources. This is done in view of the need to determine the way to meet financing challenges.

Study Guide Questions

It is recommendable to give students some questions (see below) to answer prior to class in order to guide them in the analysis required for each part of the discussion. However, instructors must decide to hand all the questions or just a part of them. Independent questions for each part are given, but they can be handed together.

1. What should the value proposition for the company be?
2. What feasible size must the farm reach before moving to other locations?
3. How can the project overcome the financing challenges it faces at the time of beginning production?
4. What investment evaluation methodology should be used to evaluate the Michin Eco Farm project?
5. Were the owners leaving out something they should have considered in designing their project?
6. Is the project profitable?

7. What are the critical variables of the project?
8. What would be the project’s ranges of variation?
9. Conduct a risk analysis. What is the result? How does it compare to the deterministic analysis in 6 above?
10. What would you recommend to Messrs. Aguilera and Laínez?

Part I Questions: Elements of the aquaculture industry

What challenges does the aquaculture industry face currently?

First, the fact that the world's largest fisheries were being exploited beyond their maximum sustainable yield must be considered. As a result, the fish population had decreased and costs had increased over the last decades. Improving reproduction and production in this industry is a key challenge the industry faces, as well as having equipment, land, qualified staff, and fish fattening and growth. Another challenge is how to reduce high aquaculture costs in terms of food, ponds and power. A way to cover them using the earnings from product sales must be carefully considered.

Identify potential beneficial elements in this industry and the best way to exploit them.

Is there a way to compete against China, which is a world power in this industry?

China is no doubt the largest producer of tilapia worldwide, and the largest exporter of tilapia to most of the world. A key factor to compete against it would be to its form of production and the quality of its final products. Being an exporting power, China guarantees frozen products. While it is not possible to compete against it on low prices, competition can be based on product differentiation resulting in added value for consumers. For instance, finding new ways of feeding, fattening and packaging fish and avoiding hormones would be very attractive to a portion of the market.

Part II Questions: Evaluation of the aquaculture project with clean energies

What should the company value proposition be?

This has to do with identifying and analyzing the project as such to obtain a product that is produced using clean, renewable energies, with increasing specialization in biofloc technology. On the other hand, the project might focus on commercial value by producing in line with market demand and competing with China's low prices. Students must understand this analysis that students must understand to choose the kind of business Mauricio Aguilera and Félix Laínez must focus on when investing. Their business proposal is key for the company's legal and production focus.

Using biofloc and clean energies entails a high initial investment since this involves purchasing solar panels, paying for specializing in biofloc, and acquiring biofloc (which is expensive) resulting in very low short term returns from high investment. However, in the long term the project will benefit from low cost production (value added value for the product). Tilapia would be produced using renewable energies and highly nutritional food manufactured in an environmental friendly, sustainable way. In addition, jobs would be created thus favoring economy in the region.

Should something cheaper be used initially to generate experience and capitalize the project a bit?

Should biofloc technology, which is more expensive but more secure in terms of ensuring a less risky operation, be used at the beginning?

What would be better for this project, fresh or frozen products? Does this decision impact the financial costs of the project?

Fresh fish has a totally different value than frozen fish and can command higher prices. The difference between fresh and frozen fish goes as far as the way to pack the product, since cooling increases labor costs, cooling costs, and additional costs of plant and packaging (vacuum packaging).

The fact that the product will be sold in the local market must be considered, as fresh products can command higher prices. If the product must be frozen, perhaps that will lower sale price to be competitive.

The goal of the company must be clearly understood to choose either fresh or frozen product lines in order to predict costs.

Is it convenient to invest in certifications?

Annual payment for certifications is in the order of 10 or 12 billion. On the other hand, the cost of complying with these certifications is equivalent to 100 thousand dollars including cost of labor, facilities, and resources, among others to have permanent certifications. Certifications are important due to their benefit for product. Selling quality products that meet international standards can result in value added ensuring consumers' willingness to pay a higher price.

Financial Evaluation of the Project

Aguilera's evaluation carried out with support from Acuícola Garza shows the following assumptions and results:

INVESTMENT COMMERCIAL PILOT SYSTEM	
CONCEPT	PESOS
TANKS BREED, PRECARIOUS AND DEVELOPMENT	$540,000.00
FLOC STORAGE POOLS	$130,000.00
GEOMEMBRANA HDEP 1MM	$80,500.00
BLOWER 3 HP	$200,690.00
AERATORS	$207,000.00
7.5 HP CENTRIFUGAL PUMP	$50,000.00
CENTRIFUGAL PUMP ¼ HP	$9,000.00
DIFFUSE HOSE	$28,600.00
THREE-PHASE DIESEL GENERATOR 21KVA 240 / 400V	$240,000.00
LABORATORY EQUIPMENT	$320,860.00
SHADE CLOTH	$39,550.00
OFFICE FURNITURE	$68,800.00
CONSTRUCTION AND INSTALLATION OF FARM.	$2085,000.00
PHOTOVOLTAIC SYSTEM	0.00
TERMINCO SOLAR SYSTEM	0.00
INVESTMENT	$4000,000.00
INVESTMENT + DEFERRED ASSETS	$4914,535.71
INVESTMENT + WORKING CAPITAL	$5714,285.71

FINANCIAL EVALUATION					
INITIAL INVESTMENT	Net Cash Flow (Years)				
	1	2	3	4	5

- $ 4000,000.00	- $ 19,209.49	$ 740,609.75	$ 777,640.24	$ 816,522.25	$ 1956,647.06
VAN *	$ 2479,892.25	* Net present value			
B / C **	$ 1.23	** Benefit / cost ratio			
T.I.R ***	17%	***Internal rate of return			
Return (years)	5	years			
R.O.A	51%	Return of assets Initial investment includes starting capital			

The project was analyzed considering a 5-year range. Results seem to be positive, which indicates it looks profitable.

However, more detailed analysis is needed to clarify the assumptions for the estimates.

Based on project figures, the break-even analysis would be as shown below. The project will begin generating profits approximately within 13 months

Sales price	**MCU**	
	51 $	1.22 US $

		BREAKEVEN			
		50.0%	5.0%	5.0%	41.1%
CONCEPTS / YEARS	**YEAR 1**	**YEAR 2**	**YEAR 3**	**YEAR 4**	**YEAR 5**
SALES	$ 1842,823.91	$ 2764,235.87	$ 2902,447.66	$ 3047,570.05	$ 4299,247.24
FIXED COSTS	$ 871,883.92	$ 878,490.52	$ 922,415.05	$ 968,535.80	$ 10116,962.59
VARIABLE COSTS	$ 990,149.48	$ 1145,135.60	$ 1202,392.38	$ 1262,512.00	$ 1325,637.60
TOTAL COSTS	$ 1862,033.40	$ 2023,626.12	$ 2124,807.42	$ 2231,047.79	$ 2342,600.18
POINT OF EQULIBIRO $	$ 1884,340.00	$ 1499,817.55	$ 1574,808.43	$ 1653,548.85	$ 1470,325.34
BREAKEVEN %	102%	54%	54%	54%	34%
Kilograms	36,133.80	54,200.70	56,910.74	59,756.28	84,298.97
CVU ($ / kg)	27.40	21.13	21.13	21.13	15.73
P. Balance	36,947.84	29,408.19	30,878.60	32,422.53	28,829.91
As % kg sold	102.3%	54.3%	54.3%	54.3%	34.2%

With the information provided by the case study, students can create a discounted cash flow to evaluate the project's financial feasibility. The instructor must decide if a final figure is given or if students will receive survival rates to estimate the fish populations going from one stage to another.

1) The first calculation has to do with estimating the project's breakeven point, which looks quite attractive (approximately 13-14 months).

2) The WACC (the discount rate to be used) must be calculated. According to engineer Aguilera, the cost of debt is a little over 17%. However, (and this can be announced with the study guide questions), the new Mexican government is supporting small businesses and credit for aquaculture is now cheaper (between 9% and 13%).

If the original criterion is used, the 5-year project is not profitable, even assuming a 40% saving in energy costs due to the use of solar panels. This is shown in the following flow:

CONCEPTS	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
(+) SALES		1842,823.91	2764,235.87	2902,447.66	3047,570.05	3199,948.55
FIXED COSTS		949,382.31	956,863.82	1004,707.01	1054,942.37	1107,689.48
VARIABLE COSTS		990,149.48	1145,135.60	1202,392.38	1262,512.00	1325,637.60
(-) TOTAL COSTS		1939,531.79	2101,999.42	2207,099.39	2317,454.36	2433,327.08
(=) GROSS PROFIT		(96,707.88)	662,236.45	695,348.27	730,115.68	766,621.47
(-) DEPRECIATION		86,985.66	86,985.66	86,985.66	86,985.66	86,985.66
GRAVABLE UTILITY		(183,693.54)	575,250.79	608,362.61	643,130.02	679,635.81
ISR		-	172,575.24	182,508.78	192,939.01	203,890.74
UTILITY AFTER TIR		(183,693.54)	402,675.55	425,853.83	450,191.02	475,745.07
(+) DEPRECIATION		86,985.66	86,985.66	86,985.66	86,985.66	86,985.66
NET FLOW		(96,707.88)	489,661.21	512,839.49	537,176.68	562,730.73
RESCUE VALUE FIXED ASSETS						1099,298.70
FIXED INVESTMENT	-4000000					
ACTIVE INVESTMENT DEFERRED	-554769					
CAPITAL INVESTMENT OF WORK		(756,340.22)	(191,935.30)			
VALUE RESCUE WORKING CAPITAL						948,275.52
GEOMETRIC GRADIENT						1617,161.72
PROJECT FLOW	-4554769	(853,048.09)	297,725.91	512,839.49	537,176.68	4227,466.66

TIR	0.70%
VAN	$ (2541,082)
B/C	0.44

The Internal Rate of Return is less than 1% as a result of a very short analysis horizon where most of the assets are not depreciated, so the tax shields of some of them, that have useful lives of 20 years, are not taken into account. Annual flows brought to present value are small and cannot cover the value of the large investment. On the other hand, the discount rate is high due to the overestimated value of debt cost.

If debt cost is not changed but analysis horizon is expanded to 10 years, the IRR looks much better as seen in the scenario belo

Granjas Ecologicas " Michin ", SA de CV

Assumptions TO GO		
WACC	0.171	
GROWTH FIXED COSTS	0.025	starting year 2
GROWTH VARIABLE COSTS	0.05	starting year 2
GROWTH PRICES	0.025	starting year 2

PRICES	54	51									
Item	0	one	two	3	4	5	6	7	8	9	10
Kg sold		38,035.28	57,053.37	57,053.37	57,053.37	57,053.37	57,053.37	57,053.37	57,053.37	57,053.37	57,053.37
Price		51.00	52.28	53.58	54.92	56.29	57.70	59.14	60.62	62.14	63.69
Income			2982,46482	3057,026.54	3133,452.20	3211,788.51	3292,083.22	3374,385.30		3545.213.56	3633,843.90
Fixed Investment	-4557169										
Investment Working Capital		(830,527.99)									
Variable costs		(1019,375.85)	(1070,344.64)	(1123,861.87)	(1180.05486)	(1239,057.71)	(1301,010.60)	(1366,061.13)	(1434,364.18)	(1506,082.39)	(1581,386.51)
Fixed costs		1001,093.95	1026, 121.30	1051,774.33	1078,068.69	1105,020.41	1132.64582	1160,962.07	1189,986.12	1219,735.77	1250, 229.17
Depreciation		(86,985.66)	(86,985.66)	(86,985.66)	(86,985.66)	(86,985.66)	(86,985.66)	(86,985.66)	(85,860.66)	(85,860.66)	(85,860.66)

Utilities before IR		1834,531.72	2851,25582	2897,953.34	2944,480.27	2 99 0, 765.54	3036,732.88	3082,300.58	3128,506.21	3173,006.27	3216,825.89
IR (30%)		550,359.52	855,376.78	869,386.00	883,344.08	897, 229.66	911,019 .86	924,690 .17	938,551.86	951.9 01.88	965,047.77
Depreciation		86,985.66	86,985.66	86,985.66	86,985.66	86,985.66	86,985.66	86,985.66	85,860.66	85,860.66	85,860.66
Net flow		637,345.18	942,362.44	956,371.66	970,329.74	984,215.32	99 8,005.53	1011,675.83	1024,412.52	1037,762.54	1050,908.43
Fixed investment redemption value											664,370.39
Value rescue capital work											830,527.99
Geometric Gradient											8685,193.61
Project flow	-4557169	(193,182.81)	942,362.44	956,371.66	9 70.32B.74	984,215.32	99 8,005.53	1011,675.83	1024,412.52	1037,762.54	2545,806.81
VAN	(688,585)										
TIR	13.8%										
B / C	0.85										

Granjas Ecologicas " Michin ", SA de CV

Assumptions

TO GO	30%	
WACC	13.60%	
GROWTH FIXED COSTS	2.50%	from year2
GROWTH VARIABLE COSTS	5.00%	starting year 2
GROWTH PRICES	2.50% 2	starting year 2

PRICES	54	51.0									
Item	0	one	two	3	4	5	6	7	8	9	10
Kg sold		38,035	57,053	57,053	57,053	57,053	57,053	57,053	57,053	57,053	57,053
Price		51	52	54	55	56	58	59	61	62	64
Income		1939,799	2982,465	3057,027	3133,452	3211,789	3292,083	3458,745	3545,214	3633,844	3633,843.90
Fixed Investment	- 4557,169										
Investment Working Capital		-830,528									
Variable costs		-1019,376	- 1070,345	- 1123,862	- 1180,055	- 1239,058	- 1366.061	- 1434,364	- 1506,082	- 1581,387	(1581,386.51)
Fixed costs		1001,094	1026,121	1051,774	1078,069	1105,020	1160,962	1189,986	1219,736	1250,229	1250, 229.17
Depreciation		- 86,986	- 86,986	-86,986	-86,986	-86,986	-86,986	- 85,861	- 85,861	- 85,861	- 85,861

utilities before IR		1834,532	2851,256	2897, 953	2944,480	2990, 766	3082,301	3128,506	3173,006	3216,826	3216,825.89
IR (30%)		550, 360	855, 377	869, 386	883,344	897,230	924,690	938,552	951,902	965,048	965,047.77
Depreciation		86,986	86,986	86,986	86,986	86,986	86,986	85,861	85,861	85,861	85,861
Net flow		637,345	942, 362	956, 372	970,330	984,215	1011,676	1024,413	1037,763	1050, 909	1050,908.43
Fixed investment redemption value											664, 370
Value rescue capital work											30,528
Project flow	- 4557,169	- 193,183	942,362	956,372	970,330	984,215	998,006	1011,676	1024.41	1037,763	2545,807
VAN	47,018										
TIR	13.80%										
B / C	1.01										

Finally, once the WACC is re-calculated (see table below, WACC = 13.6%), we have a more realistic estimate regarding the feasibility of the Eco-Granjas "Michín" project:

Crec .kg	Annual growth prices	2.50%	51.00	52.28	53.58	54.92	56.29	57.70	59.14	60.62	62.14	63.69
2.44 %	Annual growth cost	1.25%	36,133.80	52,878.73	54,168.46	55,489.64	56,843.05	58,229.46	59,649.69	60,000.00	60,000.00	60,000.00
	CONCEPTS	YEAR O	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
	(+) SALES		$ 1842,823 .91	$ 2764,235.87	$ 2902,447.66	$ 3047,570.05	$ 3199,948.55	$ 3359,945.98	$ 3527,943.27	$ 3637,378.41	$ 3728,312.87	$ 3821,520.69
	FIXED COSTS		$ 871.88 .382	$ 878.4 900.5 2	$ 922,415.05	$ 968,535.80	$ 1016, 962.5 9	$ 1029,674.62	S 1042,545.55	$ 1055,577.37	$ 1068,772.09	$ 1082,131.74
	VARIABLE COSTS		$ 990 , 149.48	$ 1145,135.60	$ 1202,392.38	$ 1262,512.00	$ 1325,637.60	$ 1342,208.07	S 1358,985 .67	$ 1375,972.99	$ 1393,172.65	$ 1410,587.31
	(-) TOTAL COSTS		$ 1862,033.40	$ 2023,626.12	$ 2124,807.42	$ 2231,047.7B	$ 2342,600.18	$ 2371,882.6B	$ 2401,531.22	$ 2431,550.36	$ 2461,944.74	$ 24B2,719.05
	(=) GROSS PROFIT		$ (19,209.49)	$ 740, 609.75	$ 777,640.24	$ 816,522.25	$ 857,348.36	$ 988,063.2B	$ 1126,412.05	$ 1205,828.05	$ 1266,368.13	$ 1328,801.64
	(-) DEPRECIATION		$ 86,985.66	$ 86,985.66	$ 86,985.66	$ 86,985.66	$ 86,985.66	$ 86,985.66	$ 86,985.66	$ 85,860.66	$ 85,860.66	$ 85,860.66
	UTILITY BEFORE GOING		$ (106,195.15)	$ 653,624.09	$ 690,654.58	$ 729,536.59	$ 770,362.70	$ 901 , 077.63	$ 1039,426.39	$ 1119,967.39	$ 1180,507.47	$ 1242, B40.98
	ISR		-	$ 196,087.23	$ 207,196.37	$ 218,860.9 8	$ 231,108.81	$ 270,323.2B	$ 311,82782	$ 335, 990.22	$ 354, 152.24	$ 372,882.29
	UTILITY AFTER GOING		$ (106,195.15)	$ 457,536.86	$ 483,458.21	$ 510,675.61	$ 539,253.89	$ 630,754.34	$ 727,598.48	$ 783,977.17	$ 826,355.23	$ 870,058.68
	(+) DEPRECIATION		$ 86,985.66	$ 86,985.66	$ 86,985.66	$ 86,985.66	$ 86,985.66	$ 86,985.66	$ 86,985.66	$ 85,860.66	$ 85,860.66	$ 85,860.66
	NET FLOW		$ (1 .49 9.209)	$ 544,522.52	$ 570,443.87	$ 597,661.27	$ 626,239 .55	$ 717,740.00	$ 814,584.14	$ 869,837.83	$ 912,215.89	$ 955,919 .35
	RESCUE VALUE FIXED ASSETS											
	FIXED INVESTMENT	(4000,000)										
	DEFERRED ACTIVE INVESTMENT	(554, 769)										
	WORK CAPITAL INVESTMENT		(724,049.22)	$ (185,477.10)								
	VALUE RESCUE WORKING CAPITAL											

GEOMETRIC GRADIENT											
PROJECT FLOW	(4554,769)	(743,258.72)	359,045.42	$ 570,443.87	597,661.27	626,239.55	717,740.oo	814,584.14	869,837.83	912,215.89	9567,805.34

DEPRECIATION COST							
FIXED ASSETS	ORIGINAL VALUE	ANNUAL RATE	OS YEAR	DEP ANNUAL 1-8	VALUE RESCUE year 5	Annual DEP 8-10	VALUE RESCUE year 10
Fattening tank	500,000 . 00	5%	20	25,000.00	375,000.00	25,000.00	250,000.00
Acclimatization tanks	10,000 . 00	5%	20	500.00	7,500.00	500.00	5,000.00
Floc Storage Pond	130,000 . 00	5%	20	6,500.00	97,500.00	6,500.00	65,000.00
Geomembrana HOPE from Imm	80,500 . 00	5%	20	4,025.00	60, 375.00	4,025.00	40,250.00
alower S HP	200,690 . 00	6%	17	11,805.29	141,663.53	11,805.29	82,637.06
Diffusing hose	28,600 . 00	10%	10	2,860.00	14, 300.00	2,860.00	-
Diesel generatorthree-phase 21KVA 240 / 440V	240,000 . 00	5%	20	12,000.00	180,000.00	12,000.00	120,000.00
Oxí metro	60,000.00	7%	15	4,000.00	40,000.00	4,000.00	20,000.00
Kitis water quality	3 6,000 .00	7%	15	2,400.00	24,000.00	2,400.00	12,000.00
Atarraya 1/4 "and 1/2 '	10,000 . 00	10%	10	1,000.00	5,000.00	1,000.00	-
Imhoff cone	3, 600 . 00	7%	15	240.00	2,400.00	240.00	1,200.00
Digital Scale O.lgx600g	25,477.56	10%	10	2,547.76	12,738.78	2,547.76	-
OHAUS 2KG Scale	16.468 . 80	10%	10	1,646.88	8, 234.40	1,646.88	-
Scale 150 KG	9,640 . 64	10%	10	964.06	4,820.32	964.06	-
SOKG plastic taras	9,000.00	13%	8	$ 1,125.00	3, 375.00	-	9,000.00
Trawl for harvest	20,000 . 00	10%	10	2,000.00	10,000.00	2,000.00	-
Biofloc clarifier	96,000 . 00	5%	20	4,800.00	72,000.00	4,800.00	48,000.00

Ico electron microscope	18,700 . 00	5%	20	935.00	14,025.00	935.00	9,350.00
Shade cloth	39,550.00	7%	15	2,636.67	26,366.67	2,636.67	13,183.33
TOTAL	1534,227.00			86,985.66	1099, 298.70	85,860.66	675,620.39

Tax rate	**30%**
Flow growth rate (g)	**2.5%**

TIR	***13.86%***
VAN	**92,131**
RELAC. B/C	**1.02**

Source	Rode	Percentage	cost	Weighing
Debt	5067,66550	96.0%	13.5%	13.0%
Own capital	211,152.73	4.0%	16.0%	0.6%
Total	5278,818.22		WACC	13.6%

The assumptions can be changed, for example, why is debt proportionally so big. The idea behind this is that there are incentives to small producers to encourage investment. Financing as a proportion and the financial cost (rates below 10%) can be assumptions that can be sensitized in the following section when dealing with sensitivity analysis.

Risk analysis:

Some initial considerations on the critical variables and their variation ranges can be explored within the body of the case study. On the other hand, a set of guide questions can be sent to provide students with this type of information so that they can make their sensitivity analysis as well as the simulation.

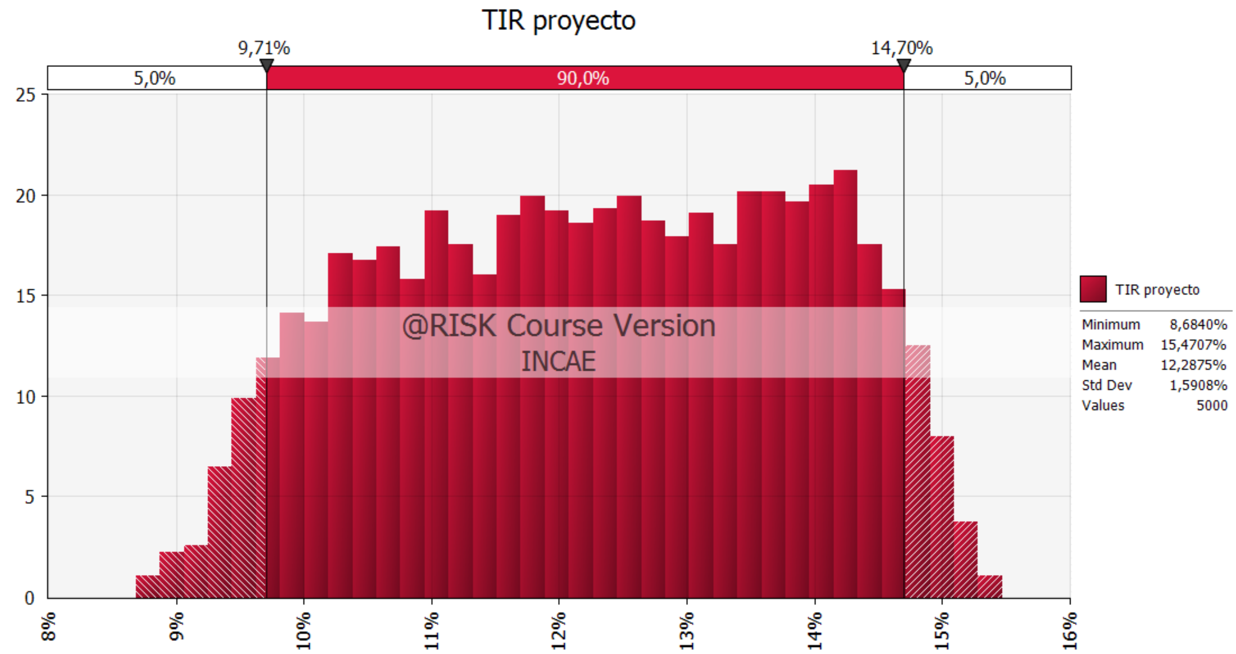
As an example for the Monte Carlo analysis, some economic risk variables could be identified, although biological variables can also be included given the nature of the product in the case. For example, the following risk variables could be identified:

Sale price in the first year could vary in a range between $ 48/kg - $ 55/kg. From then on, it could be affected by an annual growth rate that would also be a random variable. The annual growth rate of the price may vary between 1.5% and 2.5%. Also, the annual rate of growth for production can vary with a uniform distribution of probability between 4% and 6%.

The last part of the quantitative analysis in the case study may consist of a simulation with five thousand scenarios using the Monte Carlo technique. A model with four risk variables was built including annual price growth rate, annual production growth rate, annual growth rate of variable costs and the annual growth rate of fixed costs. The model also has three outputs: The Internal Rate of Return (IRR) of the project, the Net Present Value of the project and Desirability Index or the Benefit-Cost Ratio of the project (B-C).

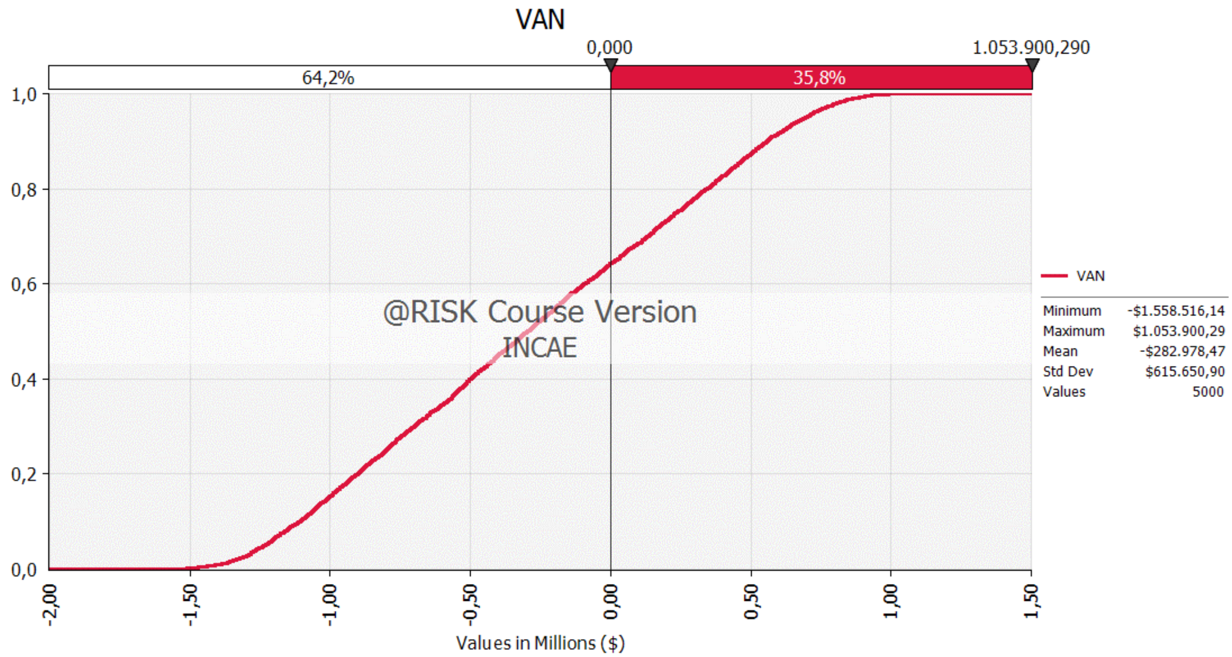
With these assumptions, the histogram shows the expected value of IRR as 12.29%. This will have to be compared with the cost of capital. The project’s minimum IRR is 8.67%. According to the results shown, maximum IRR could be 15.5%.

Project IRR



The cumulative distribution curve of the NPV is shown in the chart below. With the estimated WACC of 13.6% the mean NPV value is negative, $ 272,978.47 (about US $ 14,110) as can be seen. The graph also shows the minimum and maximum NPV value the 5,000 scenarios (in local currency, that is, - $ 1,558,516.14 and + $ 1,053, 900.3).

Also, when cash flows at the estimated WACC rate are discounted, the probability for the project not being attractive is quite high, (equal to 64.2%) tipping the scales toward rejecting the project as long as the assumptions of the case are not changed.



Other scenarios and assumptions can be explored. At the date of writing there is a chance to receive government support for a good portion of the total amount of investment required. As mentioned above, the cost of capital and consequently the WACC can change.