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FINANCIAL AND BIOLOGICAL MODEL FOR INTENSIVE CULTURE OF TILAPIA

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ABSTRACT

In the last few years tilapia has captured the attention of consumers for its nutritional qualities. At the same time it has become a substitute for species like cod and haddock when stocks are declining around the world, opening good opportunities for its commercialisation. Frozen whole tilapia products have characterized Cuban exports so far but the prices obtained in the international market do not cover the cost for intensive culture farming of tilapia. This study evaluates the likelihood of the production of large sized intensive cultured tilapia in order to produce frozen fillets for the European market. A stochastic model based on biological and financial data from intensive tilapia farming is developed assigning probabilities to several key parameters related to farming and processing. Further analysis to obtain more than 65% chance of positives values of Net Present Values over a period of ten years is conducted on Monte Carlo simulation. The influence of parameters selected as assumptions in the project is evaluated. It was found that the project will be unprofitable unless significant improvements are made in farming and processing areas in Cuba.

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1 INTRODUCTION

Once considered a low value fish, tilapia has now caught consumers' attention around the world. Historically tilapia was produced and consumed mainly in Africa and Asia. Lately it has also received international acceptance in non-traditional markets becoming a substitute for many white-fish species consumed in Europe. The price is competitive and the production of tilapia is increasing around the world. The following chapters describe the main characteristics of the European market and the most important suppliers of tilapia products. An overview of aquaculture in Cuba is also given.

1.1 European market overview

The UK is a major European market for tilapia. Tilapia is also marketed in France, Belgium, Germany and the Netherlands and in smaller quantities in Austria, Italy, Switzerland, Denmark and Sweden (Helga Josupeit, GLOBEFISH 2004). The northern part of Europe prefers fillets, while the South generally chooses whole fish. Import tariffs for tilapia into the EU are 8% for whole fish (fresh and frozen) and 9% for fillets. The main markets are the big European cities where large communities of African, Chinese and Asian people live. Recently, consumption of tilapia has also increased in non-ethnic markets (Helga Josupeit, GLOBEFISH 2004).

Nearly all tilapia marketed in Europe comes from imports. European aquaculture production of tilapia reached a peak of 320 tons in 1996, decreasing to 200 tons at present (Helga Josupeit, GLOBEFISH 2004). The major import volume is whole frozen fish but there has been an increase in fresh and frozen fillets in the past years. The total volume of tilapia imports to Europe has increased by 5,985 tons from 1996 to 2002. Taiwan is the most important exporter with a 94% of the total. From Latin America the major exporters to Europe are Brazil, with export volumes around half of China in 2002, and Ecuador (Table 1).

Table 1: Estimated import of tilapia into the EU in tons (Helga Josupeit, GLOBEFISH 2004).

Country	1996	1997	1998	1999	2000	2001	2002
China	85.9	45.4	74.1	132.0	572.8	1,863.1	197,6
Taiwan	1,476.2	1,856..2	2,833.3	4,042.0	5,087.3	5,543.5	7,382.5
Jamaica	1.5						
Brazil	21.0	10.1	10.5	8.5	0.3		107.2
Ecuador	14.1	37.1	38.6		48.0	55.1	27.7
Others	222.9	128.0	84.3	193.8	180.1	240.7	91.4
Total	1,821.6	2,076.8	3,040.8	4,376.3	5,888.5	7,702.4	7806.4

Tilapia is competing with cod and haddock but cod supplies in recent years have decreased and prices have increased, so tilapia appears to be in a good position to capture the European market from these species. European consumers and wholesalers have low awareness for tilapia and tilapia products so it is necessary to increase promotion in order to expand the market share (Helga Josupeit, GLOBEFISH 2004). In general, the European market seems to prefer larger sized tilapia compared to the US market (Helga Josupeit, GLOBEFISH 2004). It is possible to farm high quality larger sized tilapia in order to meet European consumers' expectations.

1.2 European market suppliers

Europe has increased its imports from Taiwan over the last years. Since 1996, imports from Taiwan grew from 1,476 tons to 7,382 tons, being mostly frozen tilapia. Fillet imports from Taiwan increased from 300 kg in 1997 to 228 tons in 1999. In 2002, some 7,806 tons of tilapia products were exported to the EU (Helga Josupeit, GLOBEFISH 2004).

The major importers of frozen whole tilapia in Europe are the UK (34%), France (22%) and the Netherlands (17%). The market for frozen fillets is smaller, only 600 tons were exported in 2002, mainly to Germany (39%) and the Netherlands (36%) (Figure 1 and Figure 2).

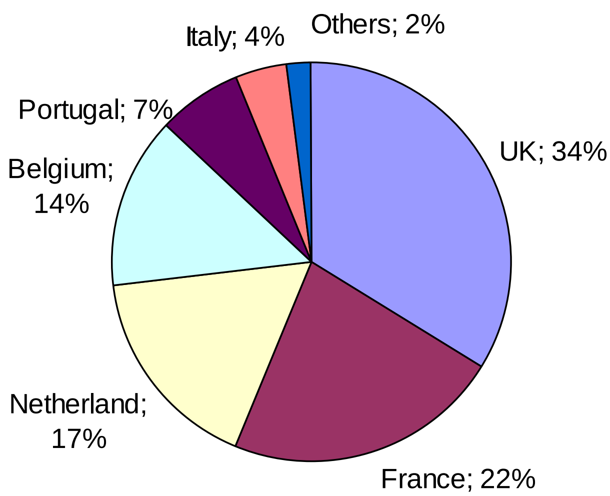


Figure 1: Taiwan whole tilapia exports to the EU by country of origin, 2002 (Helga Josupeit, GLOBEFISH 2004)

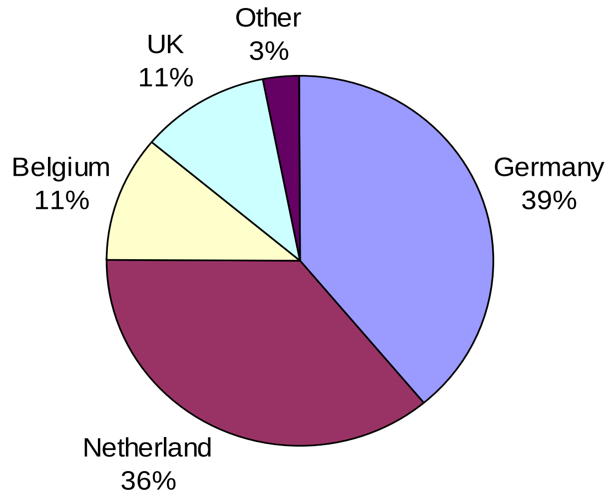


Figure 2: Taiwan tilapia fillet exports to the EU by country of destination, 2002 (Helga Josupeit, GLOBEFISH 2004)

Apart from Taiwan, few other countries are exporting tilapia products to the EU. Some fresh fillets arrive from Zimbabwe (284 tons in 2002) and Jamaica (90 tons). The fresh fillets from Zimbabwe mainly go to the UK market. Prices of fresh tilapia fillets in the European market were quite stable in 2002 and 2003 at Euro 7.0 /kg, only recently the price has gone down to Euro 6.9/kg in January 2004 (Figure 3).

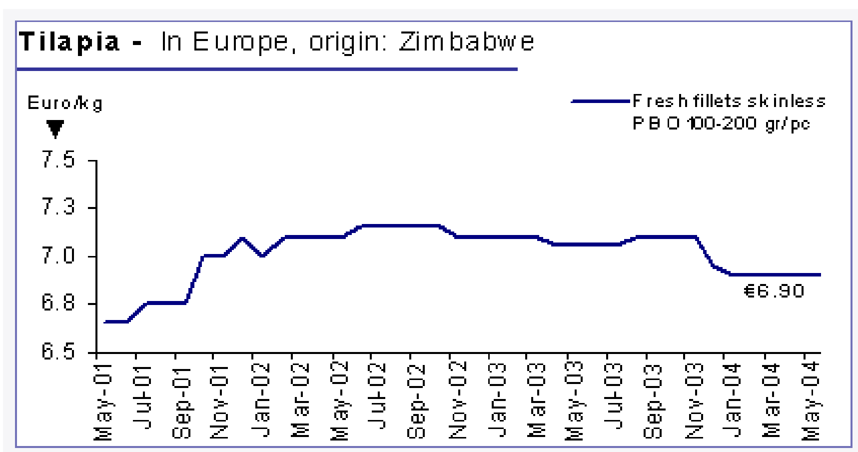


Figure 3: Price of tilapia fillets from Zimbabwe in 2001-2004 (Helga Josupeit, GLOBEFISH 2004).

Frozen tilapia fillet imports into the EU declined in 2002, as both Ecuador and Zimbabwe decreased exports of this product. Taiwan captured the slot in the market, accounting for almost 90% of EU imports in 2002 (Helga Josupeit, GLOBEFISH 2004).

Main suppliers of tilapia fillets for the EU market are the countries from Asia since imports from Latin America and Africa have declined in the last years (Table 2). The volume of fillet imports is still small but is increasing and the market prices are favourable and stable (Helga Josupeit, GLOBEFISH 2004).

Table 2: EU tilapia market summary.

Main markets (% imports shares)	1. United Kingdom (34% whole, 11% fillets) 2. France (22 % whole) 3. Belgium (14 % whole, 11% fillets) 4. Netherlands (16 % whole, 36 % fillets) 5. Germany (39 % fillets)
Main suppliers (% export shares)	1. Taiwan (97 % frozen products) 2. Indonesia 3. Thailand 4. Zimbabwe (74 % fresh fillets) 5. Malaysia
Main products	1. Whole frozen (6000 tons/2002) 2. Fresh fillets (600 tons/2002) 3. Frozen fillets (284 tons/2002)
Preferred size	Whole: 500-800g 800-UP g Fillets: <80g 80-140 g >140 g

The major markets for whole frozen tilapia are the UK and France, sharing a total of 56% of the imports for this product. The Netherlands and Germany are the biggest markets for tilapia fillets sharing 75% of imports. However, the Netherlands also have an important share in the whole tilapia market imports with 16% of the total. Taiwan is the biggest supplier for frozen tilapia products to Europe and Zimbabwe is the major supplier of fresh fillets to Europe. For countries trying to export frozen fillets (like Cuba), Taiwan is profiled as the most important competitor for such products. The market for frozen fillets is still small but the trend is that it will increase and become a substitute for other species.

1.3 Cuba: Current situation

With the objective to increase food availability, the government decided to use new dams (140 000 ha) built for agricultural purposes to farm fresh water species. Tilapia and Chinese carp were introduced in Cuba in 1964. Other species like catfish, prawns and fresh water lobster have also been farmed in intensive culture systems (Ministry of Fisheries Industry 2004).

In the second half of the 1990s an investment program was developed in order to build farms for intensive and semi-intensive culture of fish and crustaceans (currently there are more than 40 farms). Raceway systems are also used for intensive culture of tilapia. For several years the tilapia culture was abandoned in Cuba, due to financial constraints that prohibited purchases of fish meal, which is very important for intensive and semi-intensive culture of tilapia. In 1998 some new experiments were carried out in collaboration with Chinese specialists from the

Aquaculture Preparation Centre in Mamposton and in the province of Granma, achieving tilapia yields of 12 tons/ha. In addition, Cuban specialists received technical training in intensive culture of tilapia.

Since 2002 several business projects have been developed for intensive tilapia culture with financing from domestic banks or international investors. In 2002 the National Bank of Cuba offered loans to enterprises for development in aquaculture (Proyecto de Tilapia 2003).

Commercialisation of intensive culture of tilapia in Cuba has been based mainly on whole tilapia with a harvest size around 260 -300 g (Table 3). The highest sales prices obtained are about 1.35 USD/kg, which is not high enough for farmers to cover production costs.

In Cuba, the stocking density varies from 2 to10 fish/m^2 with a yield from 3 to 15 tons/ha per cycle (Table 3). The feed conversion ratio is 2.3-2.7 in most farms except in Javilla (5.1). Tilapia sold as frozen whole fish products is smaller than tilapia used for fillets.

The average harvest size is between 216-377 g, which is insufficient to produce tilapia fillets and the market prices for whole frozen tilapia in this size range are not high enough to cover the farming costs.

Table 3: Tilapia intensive aquaculture parameters in selected farms in Cuba (INDIPES 2003).

Farm	Density (Fish/m^2)	Initial weight (g)	Yield (MT/ha)	Final weight (g)	Survival (%)	Conv. Factor	Farming days
Paila	5	70	8	216	79	2.3	141
Ciego de Avila	4	9	5	265	83	2.3	190
Granma. Acuipaso	3	104	5	377	57	2.3	117
Stgo de Cuba. America	10	6	15	215	47	2.5	268
Stgo de Cuba.Parada	9	30	11	237	43	2.7	237
Guantanamo.Javilla	2	5	3	326	27	5.1	231

Currently the most attractive market for Cuban tilapia is the European market. The US market (the natural market for Cuba) is not available for Cuban export products due to a commercial blockade between the two countries.

For the past two years the attractive prices for tilapia fillets have been around 7 Euros/kg in Europe. Costs for intensive tilapia farming in Cuba and also the low price obtained for the products on the international market make it more attractive to produce fillets using large sized tilapia than to produce whole frozen fish from smaller sizes.

The average yield for tilapia fillets is 0.33 which means you need 3.3 kg of whole fish to obtain 1 kg of fillets and the minimum fillets size portions for the EU is 80 g. From this, the minimum weight for whole fish required to produce marketable fillets 500 g.

For Cuban tilapia producers the question must be:

Is it profitable to produce fillets for the European Market?

To answer this question a biological and financial model must be developed.

1.4 Objective

Based on the previous sections the objective for this research will be to:

- Evaluate the profitability of intensive culture for large sized tilapia (>500g) in Cuba to be exported to the European fillet market.

Within this objective there are two specific goals:

1. Design a financial and biological model for intensive culture of tilapia in Cuba.

2. Demonstrate the profitability of large tilapia (>500g) production and estimate the likelihood of achieving profit for varying farm scenarios.

In order to achieve this, a biological and financial stochastic model will be designed in which probabilities distributions are assigned to different parameters in order to introduce uncertainty inside the model and run simulations to find the likelihood of obtaining positive Net Present Values (NPV).

2 LITERATURE REVIEW

Little has been published on the use of risk analysis and simulations software in intensive tilapia culture. Very often investment projects and new processing introductions in Cuba are carried out without taking into consideration important questions about the implicit risk associated with the business. The decision maker generally does not have the tools and information needed to appreciate and evaluate the uncertainty of the factors involved. Important decisions taken without analysing the possibilities of success or failure can sometimes lead to serious mistakes and great losses in both financial and production terms.

Risk analysis tools software was used by Zucker and Anderson (1999) in a stochastic model of a land-based summer flounder (*Paralichthys dentatus*) aquaculture firm. In this case, a dynamic stochastic model was developed to compare alternative production and marketing scenarios using the net present value of returns. Based on the model they found that firms are unlikely to make profits unless they are located near a salt-water source used to produce summer flounder for sushi restaurants who desire medium-sized live fish.

A work on risk analysis related with aquaculture was developed for farmed shrimp in Honduras (Valderrama 2001). The objective of the study was to analyse the profitability of shrimp farming under various risk conditions. Data was collected on the technical aspects of shrimp culture such as stocking densities, feeding rates, etc as well as on the financial performance of the farms including production costs and farm revenues over a certain time period. Those scenarios were found to identify possible differences in farm management strategies. The simulations for the study were run using Monte Carlo simulation techniques. Five hundred iterations were used to generate values for individual cost and quantity parameters based on probability distributions. The main result was that regardless of the farm size, Honduran shrimp farms have the ability to generate net returns/ha per year equal to 10,000 USD. This implies yields between 1,200 and 1,400 kg/ha of large tail count shrimp.

Yoshimoto and Shoji (2002) propose 13 continuous time stochastic models based on the state-dependent volatility processes for log price dynamics and conduct a comparative analysis for their performance. The parameters estimation is performed by using the local linearization method. The comparison is carried out on the basis of Akaike's Information Criterion (AIC). They find that the general form of the state-dependent stochastic model yields the highest performance in terms of AIC for most logs and also that price dynamics with the tendency to increase over time can be captured with a stochastic model, with the drift term as a linear function.

Mazumdar (1995) enhanced the Baleriaux and Booth stochastic model used in power generation systems for the purpose of operational planning. It shows that Monte Carlo simulation can routinely be used to obtain a histogram of production costs. These histograms provide information on which decisions can be based. An example is given using decision analysis methods where the entire distribution of production costs is used for making a decision with respect to generation expansion.

A wide range of published articles relate to the biology and tilapia farming can be found in different sources.

Gupta and Acosta (2004) have described the main species of tilapia farmed around the world and its main characteristics. A description of the main farming systems and global production is also included. The production is concentrated in *Oreocrhomis niloticus* (Nile tilapia), *Oreochromis mossambicus* (Mozambique tilapia) and *Oreochromis aureus* (Blue tilapia). The growth of *O. niloticus* is faster because it utilizes better natural and artificial feed than *O. mossambicus*. Furthermore, *O. niloticus* shows a better biotype and therefore a bigger size and weight gain which, depending on farming time, can reach 250-700g in 6-8 months.

Popma and Masser (1999) include a description of the main aspects of tilapia biology as well as feeding behaviour, environmental requirements, diseases and growth and yields in aquaculture. Under good growth conditions, 1 g fish are cultured in nursery ponds to 20-40 g in five to eight weeks and then restocked into grow out ponds. In mono-sex grow out ponds under a good temperature regime; males generally reach a weight of 200 g in three to four months, 400 g in five to six months and 700 g in eight to nine months. To produce 400-500 g fish, common practice is to stock 14,000-20,000 males per ha in static water ponds with aeration or 50,000-70,000 males per ha where 20 percent daily water exchange is economically practical. After six months of feeding with good quality feeds, such ponds can produce 6,000 to 8,000 kg per ha and 20,000 to 22,000 kg per ha respectively. Tilapias are more resistant to viral, bacterial and parasite diseases than other commonly cultured fish, especially at optimum temperature for growth. Lymphocytes are whirling disease and hemorrhagic septicaemia may cause high mortality but these problems occur most frequently at temperatures below 20^{o}C. “Ich”, caused by the protozoan *Ichthyopthirius multifliis*, can cause serious losses of fry and juveniles in intensive re-circulating systems. External protozoan such as *Trichodina* and *Epitylis* may also reach epidemic densities on stressed fry intensive culture. In recent years the bacteria infection *Steptococcus inae* has caused heavy losses, primarily in re-circulating systems and intensive flow-through systems.

Creating simulations using Monte Carlo techniques for generating different scenarios in a biological and financial model where uncertainty is introduced in the parameters can let us know the likelihood of generating profits from an investment project, which can then reduce the risk in decision-making. Also, we confirm through the published literature that the specie *O. niloticus* is the right specie for intensive culture because of its characteristics that make it ideal for this kind of culture.

3 METHODOLOGY

The essential feature of investment decision is time. Investment involves payment of cash at one point in time which is expected to generate benefits in the future. Generally the payment is a single sum and the benefits are a stream of smaller amounts over a period of time. Given the importance of investment decisions, it is necessary to have appropriate methods of evaluation. Different authors agree that there are, in practice, basically four methods used by businesses to evaluate investment opportunities (Atrill 2003).

1. Accounting rate of return (ARR)
2. Payback period (PP)
3. Net present value (NPV)
4. Internal Rate of Return (IRR)

Accounting Rate of Return (ARR) uses annual average accounting profit that a project will generate and shows it as a percentage of the average investment over the project's life time. In order to decide if the project is acceptable it needs to be compared to the results with a minimum required set by the business.

Payback Period (PP) is the length of time it takes for an initial investment to be repaid from the net cash inflows from the project. The project manager must have a minimum payback period in mind in order to decide if the project can be accepted or nor not.

Net Present Value (NPV) uses discounted cash flows to evaluate capital investment projects. It uses a rate of return to discount all cash inflows and outflows to their present values and compares the present value of all cash inflows with the present value of all cash outflows. A positive value indicates that a project should be accepted.

Internal Rate of Return (IRR) is related to the NPV method since IRR is the discount rate when applied to the projected future cash flows which makes NPV equal to zero (NPV=0).

NPV is used here since it takes into account all costs and benefits of each investment opportunity and also makes a logical allowance for the timing of those costs and benefits.

The likelihood to achieve profitability is estimated trough obtaining a positive value of NPV. The profitability model will be developed in a Microsoft Excel spreadsheet using real values from the intensive aquaculture of tilapia in Cuba in order to make a further risk analysis and know the likelihood of obtaining profits in this particular project by obtaining positives Net Present Values (NPVs). The risk analysis will be conducted using Crystal Ball™ software and an Excel add-in graphically oriented forecasting and risk analysis program.

3.1 Capital investment

Since long-term investments represent big sums of money, investors need procedures to analyse different options. The benefits expected from a project are analysed by cash inflows. In the next chapter we explain cash flows in more detail.

3.2 Cash flows

The sets of rules and principles used by accountants to prepare financial statements can differ from country to country. Preparing a financial statement for any company that evaluates its performance over time can be a difficult task since it is necessary to interpret and understand the differences in accounting practices between companies and cultures and the effect they can have on reported earnings (Keown *et al.* 2001).

An income statement is the amount of profit generated by a firm over a given time period. Its basic expression is as follows:

Sales – Expenses = Profits.

An income statement measures a company's profits. However, profits are not the same as cash flows. A cash flow statement is a summary of cash flow over a period of time. It provides information about the operation, investment and financing cash flow and reconciles them with the changes on its cash and marketable securities during a specified time period. The cash flow statement tells us how the business has generated cash during the period and where that cash has gone.

According to several authors, such as Gitman (2003), cash flow is the primary focus of financial management. There are two objectives: to meet the firm's financial obligations and to generate positive cash flow for its owners. Financial planning focuses on the firm's cash and profits, both of them are key elements of success.

The cash flows can be divided into three well defined areas: operating flows, investment flows and financing flows (Figure 4).

The operating flows are cash movements directly related to sale and production while investment flows are related to purchases and sales of fixed assets and business interests. The financing flows result from debt and equity financing transactions. A combination of all outflows during a period affects the company's cash and marketable securities balance. Marketable securities are considered the same as cash because of their highly liquid nature. Both cash and marketable securities represent a reservoir of liquidity that is increased by cash inflows and decreased by cash outflows (Gitman 2003).

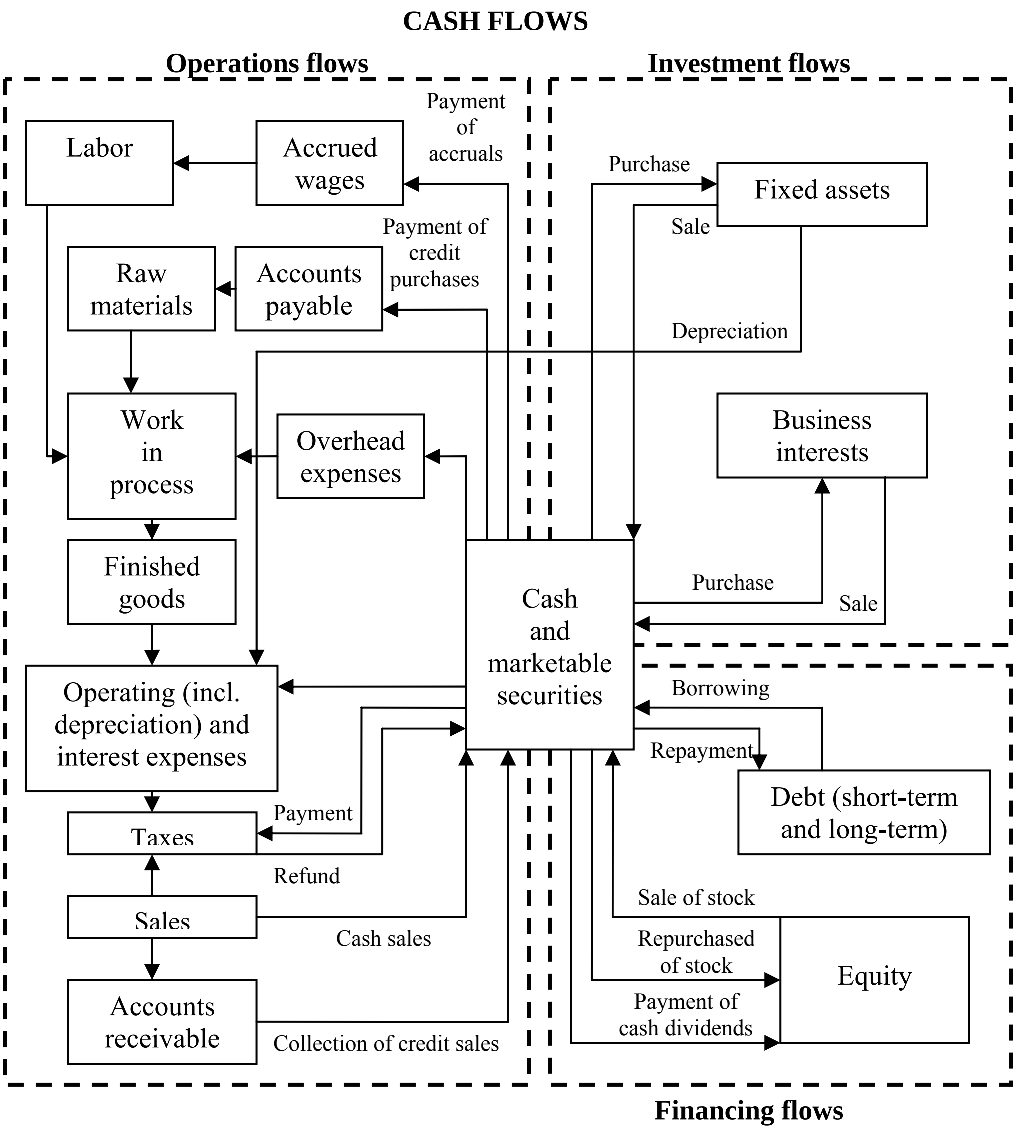


Figure 4: A company's cash flows diagram (Gitman 2003).

The cash flow from an operating perspective is the after tax cash flow generated from operations not including the company's investment in assets (Keown *et al.* 2001).

Gitman (2003) said that the Operating Cash Flow (OCF) is the cash flow generated from normal operations, producing and selling its output of goods or services and can be defined by the equation:

$$OCF = EBIT \text{ (Earnings Before Interest and Taxes)} - TAXES + DEPRECIATION$$

All benefits expected from a proposed project must be measured on a cash flow basis. The equation above is a simple technique for converting after tax net profits into operating cash flows. The calculation requires adding depreciation, amortization and depletion deducted as expenses on the income statement back to net profits after taxes.

3.3 Capital budgeting

Companies use relevant cash flows to make decisions about proposed capital expenditures. These decisions can be expressed in project acceptance or rejection.

Since Net Present Value (NPV) gives explicit consideration to the time value of money, it is considered a sophisticated capital budgeting technique. NPV can be calculated by subtracting the project's initial investment from the present value of its cash inflows discounted at a rate equal to the firm's cost of capital (Gitman 2003).

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+k)^t} - CF_0$$

$$= \sum_{t=1}^{n} \left(CF_t \times PVIF_{k,t} \right) - CF_0 \qquad (1)$$

CF_o = initial investment

CF_t = present value cash inflows

k = cost of capital

$PVIF_{k,t}$ = present value interest factor for a single amount discounted at k percent for t periods

$$PVIF_{k,t} = \frac{1}{(1+k)^t}$$

The CF_o value represents the initial sum of cash invested in the project, CF_t values are the cash inflows that the project will obtain at the end of the year (t) and capital cost (k) is the opportunity cost of an investment, i.e. the rate of return that a company would otherwise be able to earn at the same risk level as the investment that has been selected. If, after a period of time (t), the sum of the present value of cash inflows from the project, calculated with a rate of return equal to k, is bigger than the value of initial investment (CF_o), we obtain positive values of NPV meaning that the project should be accepted.

NPV deals with cash flows instead of accounting profits. Therefore, NPV is sensitive to the true timing of the benefits resulting from the project. Also recognizing the time value of the money it allows comparison of the benefits and costs in logical manner. The disadvantage of using the NPV stems from the need of a detailed, long term forecast of cash flows accruing from the project's acceptance (Keown *et al.* 2001).

3.4 Risk

All businesses operate in an environment loaded with risks and sometimes high benefits are associated with high risks. It is unimaginable to trace a corporate strategy or make an investment without making a previous evaluation of the risks associated with the possible business.

The risk analysis process varies according to the firm's particular needs as well as the tools used to carry out the risk analysis. The risk analysis process provides an answer to the following three questions:

1. What can go wrong?
2. What is the probability of it happening?
3. What are the consequences?

However, in real life, risk analysis goes beyond merely answering those questions, identifying and evaluating business process and potential system's vulnerabilities and threats.

Financially speaking, risk is the chance for financial loss or more accurately the risk term is used interchangeably with uncertainty to refer to the variability of returns associated with a given asset (Gitman 2003).

In the capital budgeting context the term risk refers to the chance that a project will be unacceptable (NPV<0 or IRR< cost of capital) (Gitman 2003).

One method of evaluating risk is through the use of statistical probabilities. It may be possible to identify a range of possible outcomes and assign a probability of occurrence to each one of the outcomes in the range. Using this information we can derive an "expected value", which is the weighted average of the possible outcomes where probabilities are used as weights (Atrill 2003). It the expected value of NPV that has the advantage of producing a single outcome with a clear decision rules (if positive it should be accepted, if not should be rejected).

The process of obtaining expected values of NPV can be carried out using specialized software like Crystal Ball. This software is an easy-to-use simulation program that helps to analyse risks and uncertainties associated with an investment plan in company management.

Probabilities distribution can be assigned to parameters in the model in order to obtain the likelihood of achieving positive values from NPV.

The type of distribution must be selected by evaluating the parameters as discrete or continuous variables and according to the variable or parameter behaviour.

In the case of perfect continuous variables the behaviour can fit the standard normal density distribution and can be described as follow:

$$P(-\infty,\infty) = \int_{-\infty}^{\infty} \frac{1}{\sqrt{2\pi}} \cdot e^{\frac{-x^2}{2}} dx \qquad (2)$$ [1]

The graph from this function is the well known bell shaped normal distribution as shown in next figure.

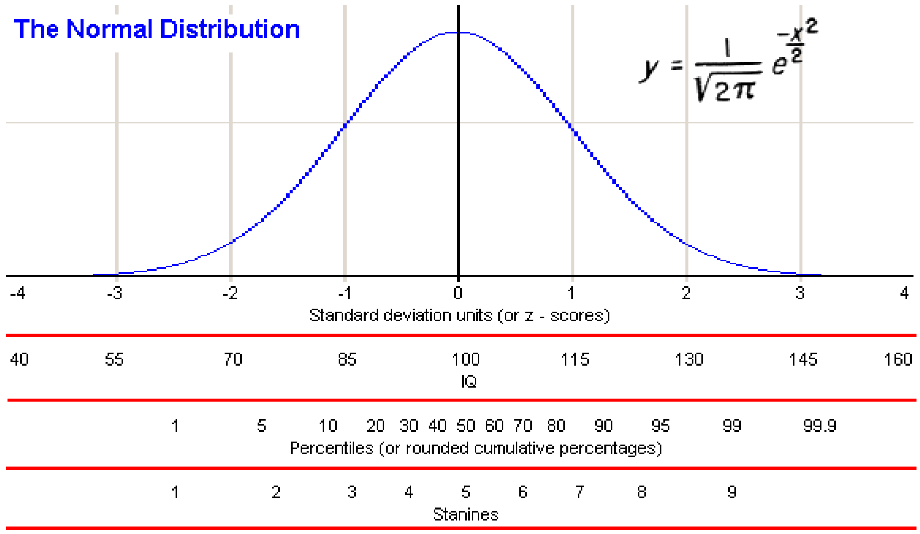


Figure 5: Normal distribution curve.

The normal distribution represents a family of distribution functions, parameterized by the mean and standard deviation, denoted by N (μ, σ). The mean (μ), as is shown in Figure 6, is referred to as a location parameter since it determines the location of the peak of the curve. The standard deviation (σ) is referred to as a scale parameter since it determines how spread out or concentrated the curve is.

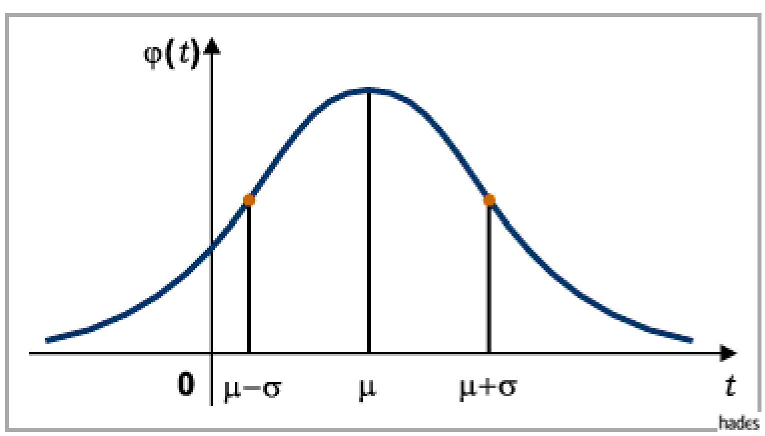


Figure 6: The mean and the standard deviation in a normal distribution curve.

The probability of an interval in the standard normal model is defined as the integral of the standard normal density over that interval.

$$P[a,b) = \int_a^b \frac{1}{\sqrt{2\pi}} e^{\frac{-z^2}{2}} dz \qquad (3)$$

Its probability is shown in Figure 7 as the area shaded in black.

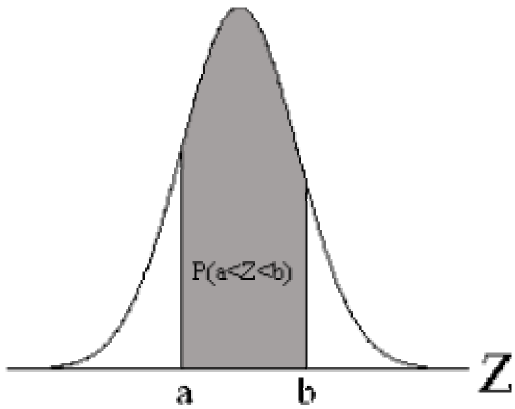


Figure 7: Probability of an interval [a, b] in a normal distribution curve.

Even though normal distribution is the most common probability distribution used, it cannot describe specific events and other distributions such as triangular distributions, uniform distributions, binomial distributions, and lognormal distributions need be used instead.

3.5 Models

The starting point for a simulation exercise is to create a model of the investment project using spreadsheet software such as Microsoft Excel. The modelling process implies identifying the key variables of the project and their relationship. This process also requires equations showing the variables determining the cash expenses and their relationships. The relationship between the cash outflows and inflows must also be modelled.

The major limitations for any spreadsheet models are:

1. It is only possible to change one cell at a time. As a result exploring the entire range of possible outcomes is very difficult (Desicioneering 2000).

2. "What if" analysis always results in single point estimates, which do not indicate the likelihood of achieving any particular outcome? While single-point estimates might tell you what is possible, they do not tell you what is probable (Desicioneering 2000).

A spreadsheet can be called a "spreadsheet model" when it is just a data storage spreadsheet in an analytical tool with combinations of data, formulas and functions.

It is possible to assign a range of possible values for each uncertainty cell in the spreadsheet model. All data available about the assumption will be introduced at the same time. Using Monte Carlo simulation you can find the complete range of possible outcomes and the probability of achieving all of them (Desicioneering 2000). Simulation is an analytical method that calculates possible scenarios when other analysis methods are too complex to reproduce.

Without the aid of simulations we will only obtain the most likely scenario but not a range of possible outcomes. Spreadsheet risk analysis automatically analyses the effect of dynamic varying inputs on the model's output. Monte Carlo simulation is a type of spreadsheet simulation which randomly generates values for uncertain variables repeatedly to simulate a scenario.

Figure 8 shows a schematic design of the way the project will be conducted using a model designed in Microsoft Excel and running a simulation in Crystal Ball using Monte Carlo techniques. The uncertainty in the data is introduced by assigning probability distributions to different parameters and obtaining the likelihood for positives values of NPV.

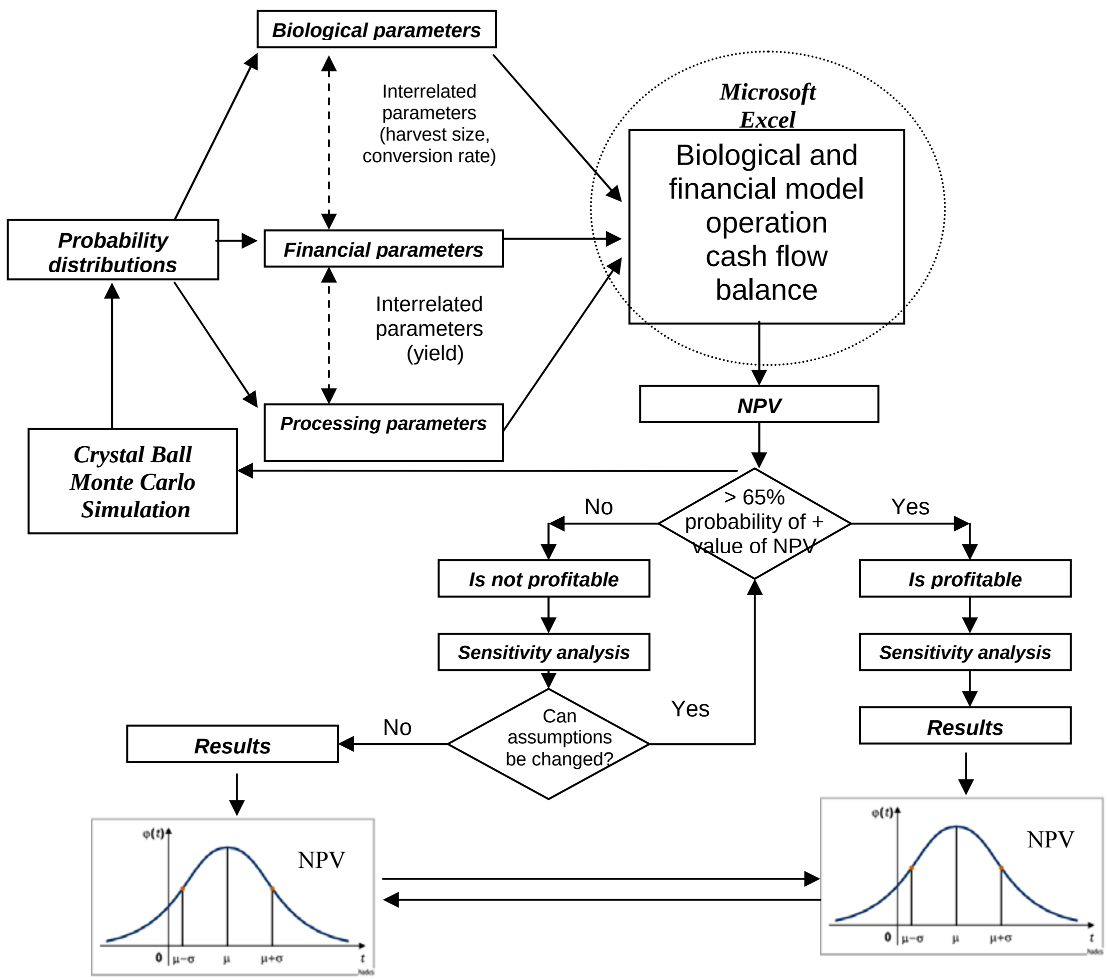


Figure 8: Project design chart.

Net Present Value will be calculated as well as several financial ratios to evaluate the project's profitability. In order to run the Monte Carlo simulation on Crystal Ball, probability distribution will be assigned to selected farming and processing parameters. The probabilities distributions will be made using available data. Net Present Value (NPV) was selected as the forecast variable for our simulation in order to know the probability of achieving more than 65% probability of positive values of NPV. If there is less than 65% probability to obtain positive values of NPV the project will be considered unprofitable. A sensitivity analysis will be carried out using Crystal Ball in order to know which parameter has the highest influence on the NPV and analyse if assumptions for those parameters can be changed. If assumptions can be changed, the simulation will be executed again to obtain new results. If assumptions cannot be changed, the project will be considered unprofitable and must be rejected. If there is more than a 65% chance of achieving positive values of NPV, the project will be considered profitable. In this case, further sensitivity analysis will be carried out in order to know the important parameters that can influence the project and analyse in which way they can be improved.

Figure 9 shows screenshots from the model. It also shows the data used for farming, processing and investment and how they are interconnected and also how all the outputs from the data assumptions are introduced in the model summary at the first stage of running the simulation. All parameters on “green” background cells are parameters that have been chosen as assumptions in the model and have a probability distribution. After calculating the production, quality and cost for intensive tilapia farming, the output farm production and farming costs are used in the processing worksheet to calculate the production and also the filleting variable cost. Those outputs are introduced in the model summary worksheet as shown in the figure.

Parameters related to farm size are used to estimate the investment cost in equipment and facilities related to the farm, such as ponds and buildings. The simulation output (Figure 10) will be ten NPV forecasting chart obtained after running a simulation where certainty will be known to obtain positives values of NPV making the minimum value in each chart equal to zero. The range of ten blue background cells represents the forecasting cells since in each one we obtain the NPV value for each year. The sensitivity of each selected parameter as an assumption variable can also be analysed using the sensitivity chart obtained after running Monte Carlo simulations.

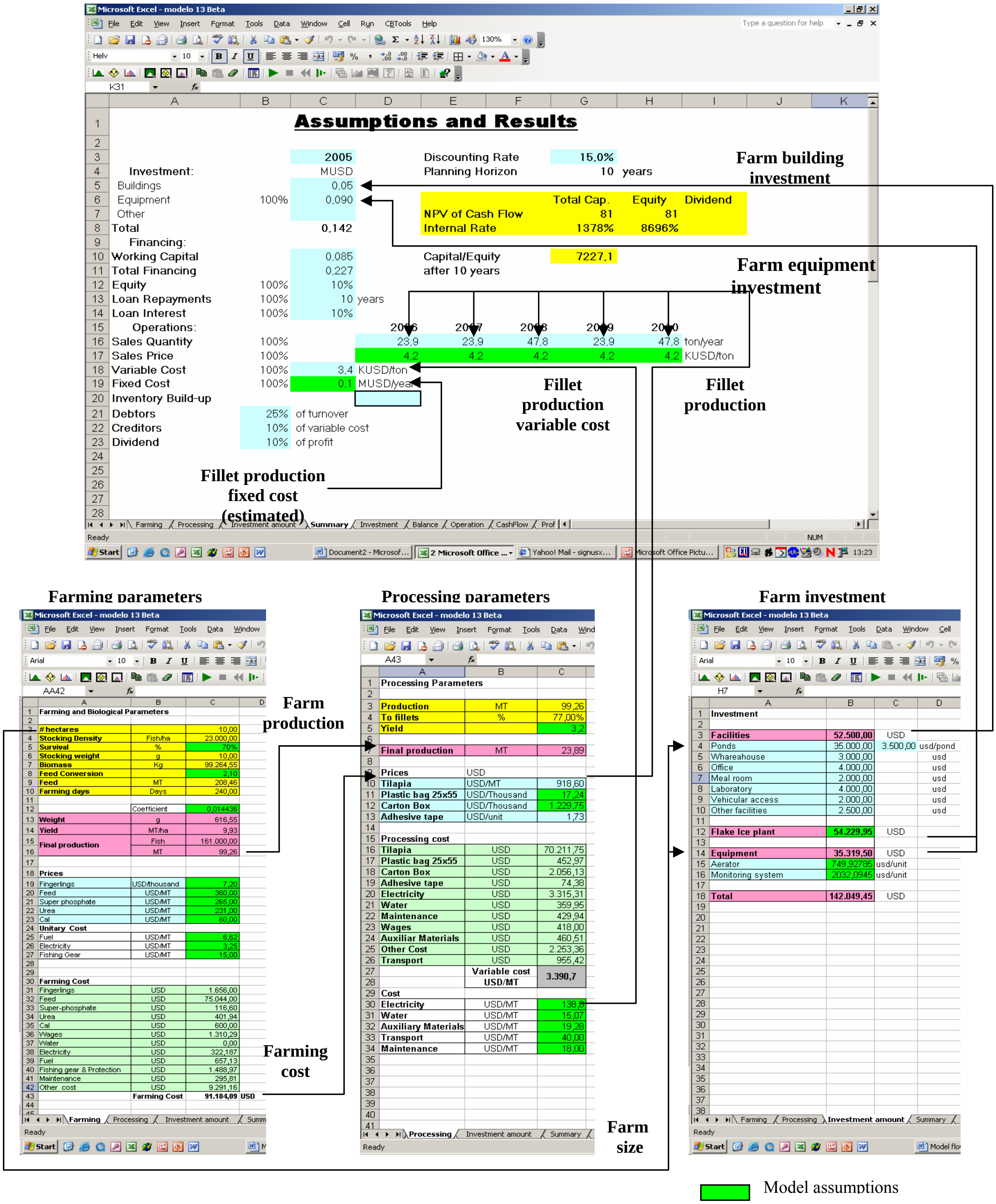


Figure 9: Model parameters relationship.

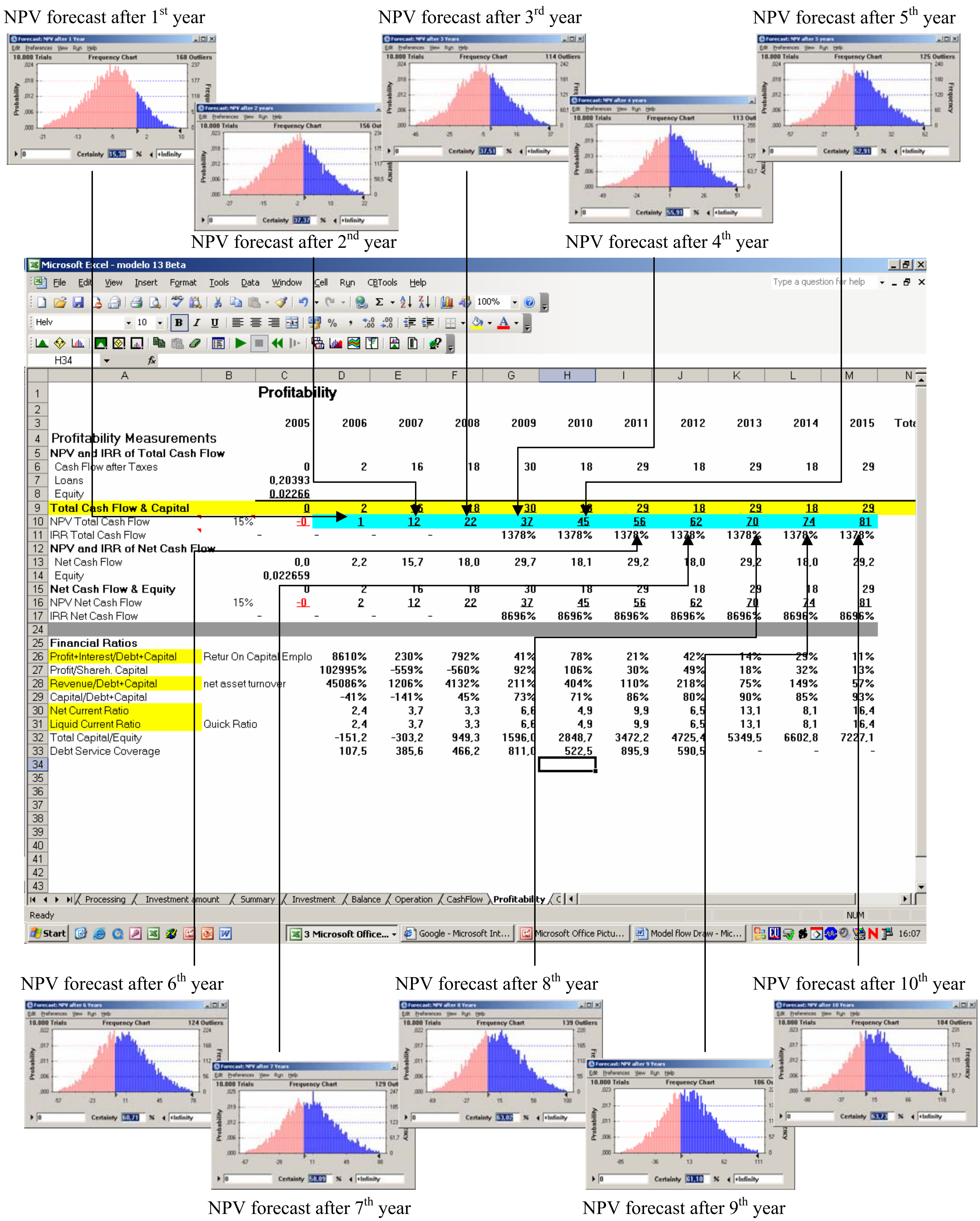


Figure 10: Model NPV forecast.

4 MODEL

4.1 Data

INDIPES directorate has total control over farming and fish processing activities in Cuba. Weekly information is supplied by the farms and processing plants and analysed by specialists in the INDIPES headquarters where the parameters related to each activity can be controlled and further actions can be taken in order to solve any problems on the farms or in the processing plants.

In addition, several quality and productions inspections are conducted by specialists from the Fisheries Ministry, Fisheries Investigation Centre and INDIPES headquarters year round to control "in situ" the production and compliance with procedure and production parameters.

The data used in this work are obtained from the information supplied by the farms and processing plants and also by calculations carried out by specialists at INDIPES headquarters based on available data.

4.1.1 Farming parameters

Biological and economic parameters related to intensive farming of tilapia as well as processing and economic parameters of fillet production will be introduced using a financial model developed by Professor Páll Jensson University of Iceland, Faculty of Economics and Business Administration) in order to calculate the operation, cash flow and balance for the project during a time frame of 10 years.

The general assumptions for tilapia intensive culture according to the information available from producers in Cuba are shown in Table 4. Comparing this information with the data in Table 3 the challenge is to produce in almost the same period of time (eight months) larger sized tilapia with double the weight of current production.

Table 4: Intensive farming parameters.

Survival fingerling-harvest	Stock density	Stocking weight	Feed conversion	Harvesting weight	Yield	Farming days
70%	2.3 fish m^2	10 g	2.1	460-500 g	10 MT/Ha	240

For each 0.1 ha we will stock 2,300 fingerlings in order to obtain, after 240 farming days, a harvesting yield of 10 tons per ha of tilapia. Fingerling cost is considered to be 7.20 USD.

Next we will explain the procedures to calculate the cost for intensive farming in order to obtain the expenses per kg of farmed fish. The cost of fertilizer is calculated as follows:

Table 5: Fertilizer calculations: Urea.

Urea needed	# has	Yield	Urea price	Cost per kg fish
174 kg/ha	10	10tons/ha	231USD/ton	0.004 USD/kg

Table 6: Fertilizer calculations: Super Phosphate.

Super Phosphate needed	# has	Yield	Super Phosphate price	Cost per kg fish
44 kg/ha	10	10tons/ha	265USD/ton	0.00166 USD/kg

When calculating labour wages on the farm it was estimated that there would be one worker per 2 ha, one technician per 10 ha and one specialist per 30 ha.

It was assumed that 10 % of fish would be less than 460-500 g and 90 % would be over 500 g. This point will be analysed later using simulation to determinate the likelihood to obtain fish sized over 500g.

4.1.2 Processing parameters

INDIPES group has 20 enterprises with 25 processing plants around the country including a tuna canning plant and a “ready-to-eat” plant located in Havana City. The other processing plants focused mainly on aquaculture production since it is the main source of raw material for those plants. The main processed species are carp (77%) and tilapia (18%).

Tilapia processing typically includes the following steps:

- Reception
- Manual sorting
- Bleeding and washing
- Gutting and filleting
- Washing
- Trimming
- Grading
- IQF
- Packing
- Cold store

The itemized processing costs for tilapia fillet are shown in Table 7.

Table 7: Itemized tilapia processing costs (INDIPES 2004).

Item	Units	Ratios	Price USD	Cost USD/kg
Whole tilapia	MT	3.30	0,92	3.030
Plastic bag 25x55	Thousand	1.10	0,017	0.019
Carton box 15 kg	Thousand	0.07	1,23	0.086
Adhesive tape	Roll	1.80	0,0017	0.003
Total raw materials				3.138
Electricity				0.089
Maintenance				0.018
Wages				0.017
Indirect cost				0.056
Water				0.013
Amortization				0.002
Auxiliary materials				
Protection devices				0.,015
Hygienic and cleaning products				0.004
Direction cost				**0.075**
Transportation				0.040
Sub total				**3.497**
Financial cost				0.,019
Commercial margin (11%)				0.384
Sales price				**3.900**

The distribution forms (normal, triangular etc) will be selected for each parameter according to the known data and the suggestion given by Decisioneering (2000), Douglas (1994) and Valderrama (2001).

4.2 Growth equation

Several equations have been developed to describe growth such as Brody, Bertalanffy, Chapman-Richards, monomolecular, Gompertz, logistic, Johnson and Silva (Rosa *et al*. 1997).

In mathematical biology total growth is defined as cumulative growth or the sum of continuous increment. An equation for cumulative growth must be expressed as a function of time or age and must contain a specific parameter of the initial condition. Growth can be used as a variation of size, length, weight or any another physical dimension and can increase or decrease (Rosa *et al*. 1997).

Silva (1986) and Mitscherlich (1909) expressed growth as a proportional difference between the maximum size and the growth parameter (c).

Mathematically growth can be expressed as:

$$dW / dt = c(U - W) \quad (4)$$

After integration:

$$W = U \cdot (1 - e^{-ct}) \quad (5)$$

If n factors are combined then:

$$W = U \cdot [(1 - e^{-c_1 t})(1 - e^{-c_2 t})....(1 - e^{-c_n t}) \quad (6)$$

or

$$W = U \cdot (1 - e^{-ct})^n$$

Where:

$C = c_1 + c_2 + \ldots + c_n$, (growth parameter) W = Growth
U = Asymptotic growth
n = Number of factors

Several equations are tested in order to find the most appropriate equation to fit the data obtained in previous experiments at the Fish Farming Station of the Universidad Federal Rural in the state of Pernambuco (Rosa *et al*. 1997). In the experiment tilapia was raised for 165 days. The size of the ponds was 0.02 ha and they were stocked with fish weighing 39.7 g and 12.9 cm in length and were all male Nile tilapia (*O. niloticus*). The stocking density was 10,000 fish/ha.

The best model to describe the growth for *O. niloticus* was the Chapman Richards model with an index of fit of 0.9864.

The Chapman-Richards equation for *O. niloticus* can be expressed as follows:

$$W_n = W_{n-1} \cdot \left[\frac{(1 - e^{0,02734 \cdot t_n})}{(1 - e^{0,02734 \cdot t_{n-1}})} \right]^{0,21} \quad (7)$$

Where W_n is the final weight, W_{n-1} is the initial weight, t_n is time of growth and t_{n-1} is time at initial weight.

If the above equation is used to estimate the growth in the intensive farms using the initial parameter of stocking weight (10g) and a farming time of 240 days we have:

$$W_{240} = 10 \cdot \left[\frac{(1 - e^{0,02734 \cdot 240})}{(1 - e^{0,02734 \cdot 1})} \right]^{0,21}$$

$$W_{240} = 365,2g$$

The expected value of 365 g for 240 days of farming is different compared to results from calculations made in Cuba (590 g) using intensive tilapia farm growth data.

In Figure 11 we can observe and compare the theoretical growth curves for intensive culture of tilapia calculated by INDIPES specialists and the values obtained in a pond's sampling in two tilapia intensive farms in Cuba.

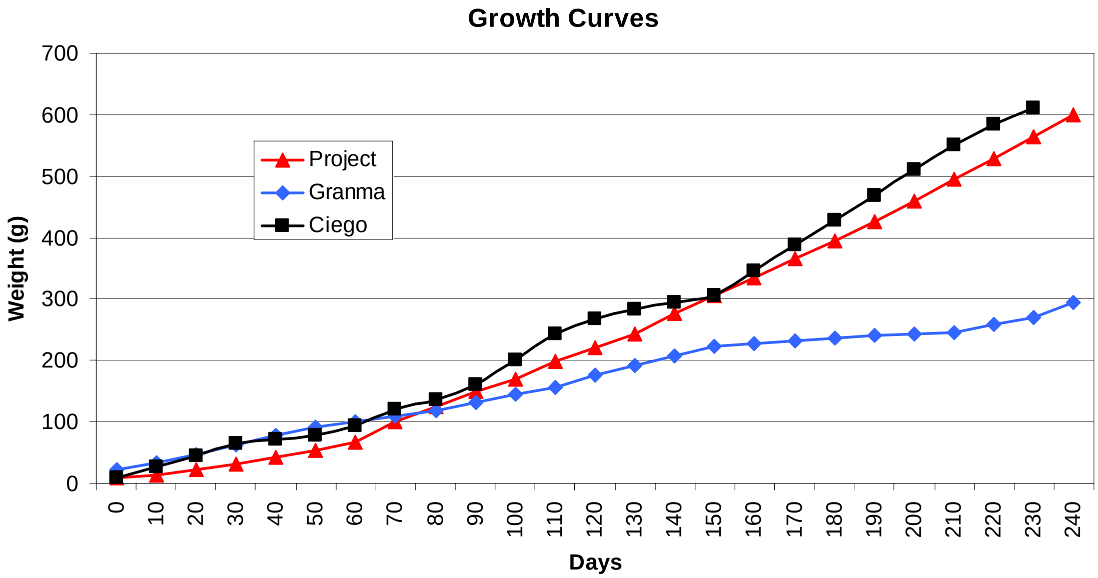


Figure 11: Tilapia real and theoretical growth curves.

The lines show the expected growth rate for the intensive culture project (red) and real values from intensive farms in Ciego de Avila (black) and Granma (blue). Granma, where the culture of Tilapia is made with mix between males and females in the same pond, had the worst results with 300 g after 240 days. On the other hand, Ciego, where farming conditions are better and only-male culture is used, had much better results with the fish weighing 300 after 150 days and 500 g after 210 days of culture.

Figure 12 shows the difference between the calculated growth curve using Chapman-Richard's equation and the growth curve using values supplied by the Aquaculture Directorate in Cuba.

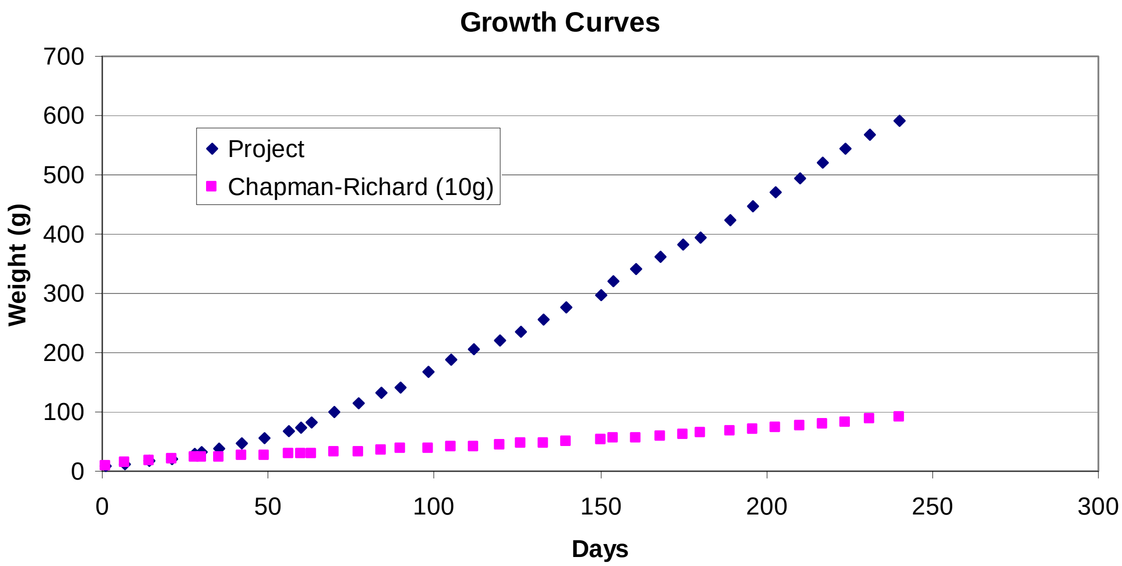


Figure 12: Values of weight obtained using Chapman-Richard's equation and values calculated by the Aquaculture Directorate.

As can be expected the Richard-Chapman equation using the default parameters and a stocking weight of 10 g was unable to replicate the data available from an intensive tilapia culture farm in Cuba.

In order to obtain an equation that matches the values obtained in intensive farms in Cuba several values of C and n were evaluated using the original values from Chapman-Richard as a base and assigning a W_{n-1}= 10 g.

We found that by fixing the value of n=0.537805 and varying the values of C from 0.009022 to 0.01624 in the Chapman-Richard equation it was possible to match all the different data from the Cuban farms as shown in Figure 13.

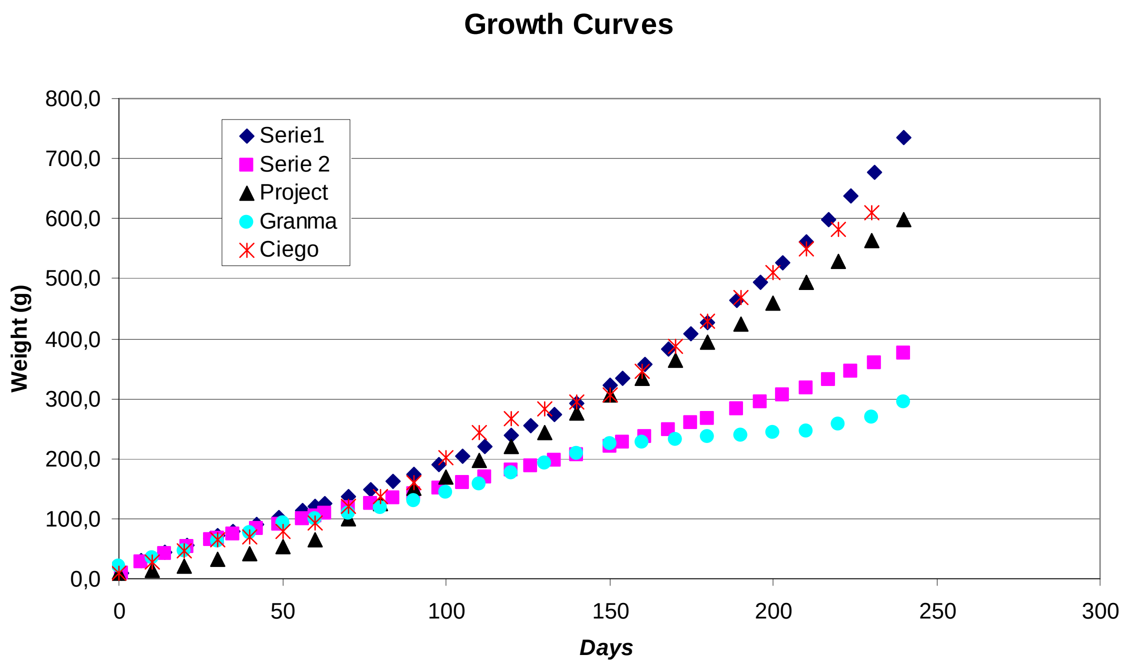


Figure 13: Comparison of calculated and real growth curves.

Series 1 and Series 2 were calculated using values of C=0.0162 (dark blue) and C=0.009022 (pink) respectively and Ciego (red), Granma (light blue) and Project (black) were plotted using data supplied from the Aquaculture Directorate in Cuba.

Differences between farms are found mainly because in Ciego de Avila only male tilapia are used and in Granma both male and female tilapia are used.

For Series1 the equation is stated as follows:

$$Wn = 10[\frac{(1-e^{0,01624tn})}{(1-e^{0,01624tn-1})}]^{0,5378054} \quad (8)$$

For Series 2 the equation is stated as follows:

$$Wn = 10[\frac{(1-e^{0,009022tn})}{(1-e^{0,009022tn-1})}]^{0,5378054} \quad (9)$$

Tilapia growth rates are influenced by a variety of factors (Chapman 2000) such as water temperature, sex, supplement feeding and stocking density. Since (c) values represent the growth parameters in the Chapman-Richard equation, varying those values in a wide array of possible incomes we are covering almost all combinations of possible situations of intensive culture of *O. niloticus* in Cuba.

We cannot determine with certainty the parameters of the equation. Therefore we will introduce uncertainty in the equation assigning a probability distributions function to the parameters in the equation in order to obtain all ranges of possible outcomes.

We can assign a minimum value of c=0.009022, a maximum of c = 0.016240 and a most likely value of c= 0.014436 because this is the value where the curve nearly matches the calculated data from the Aquaculture Directorate. Therefore triangular distribution was selected for the parameter (c) (Figure 14).

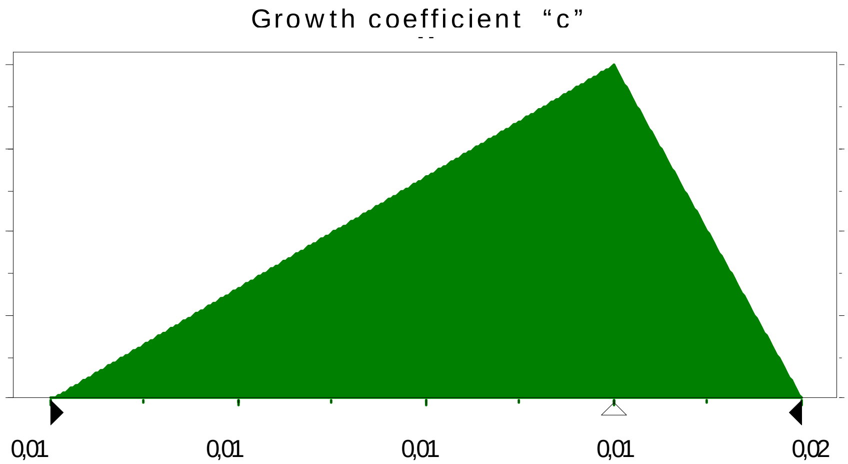


Figure 14: Triangular distribution for growth equation parameter C.

(Min = 0.009022, max = 0.016240 and most likely = 0.014436. The extreme values (maximum and minimum) are the values that fit the growth behaviour in the intensive farms analysed above).

A forecast was carried out using Crystal Ball and Monte Carlo simulation (1000 trials) in order to know the likelihood of obtaining sizes higher than 500 g in a farming time of 240 days. A certainty of 73.5 % of harvest fishes weighing 500 g or more was achieved. Figure 15 shows the forecasting chart and the probability of obtaining weights higher than 500g.

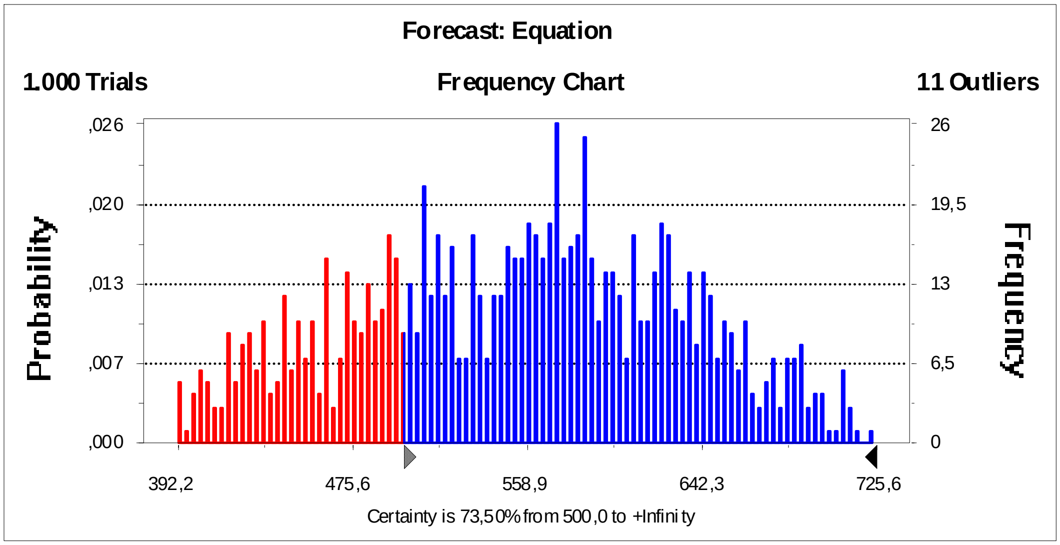


Figure 15: Forecasting chart for growth equation within 240 days of farming.

(Area between arrows shows the certainty of harvesting fish weighing more than 500g).

At this point a growth function has been obtained for tilapia that takes into account several possible scenarios. Also, we found out that based on Cuban data there is a 73.5% probability that tilapia will weight 500 g or more after 240 days of farming. The remaining fish, which are smaller than 500 g can be used for whole frozen fish processing since they are not suitable for filleting.

4.3 Biomass

The biomass was calculated using the cumulative survival data (70%) for 240 farming days. Crystal Ball and Monte Carlo simulations (1000 trials) were used to know the likelihood of obtaining yields higher than 9000 kg per ha. In this case calculations were made assuming a pond of 0.1 ha. The biomass was calculated using an equation supplied by Aquaculture Directorate specialists:

$$Biomass_{240days} = W_{240days} \times SD \times CSV_{240} \times Ha \quad (10)$$

Where:

$W_{240days}$= weight at 240 farming days

SD= stocking density (g)

$CSV_{240days}$= cumulative survival at 240 farming days (%)

Ha = number of hectares

Uncertainty was introduced in this equation by assigning a lognormal probability distribution to a cumulative survival percent parameter. The distribution selected was made by fitting a curve to the available data. In Figure 16 the limits distribution curve can be seen and the limits selected using data available from intensive aquaculture farming in Cuba. Since tilapia is resistant to diseases and chemicals we consider in our model that it is impossible for this kind of culture to collapse.

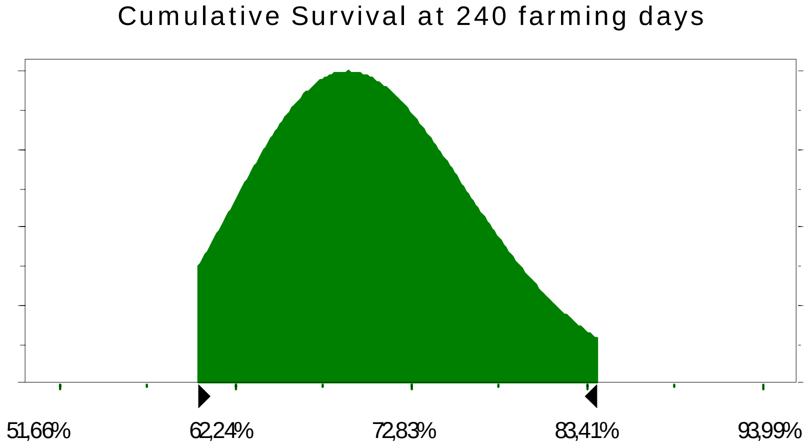


Figure 16: Lognormal distribution curve assigned to parameter CSV in the biomass equation.

The minimum value was 60% and the maximum was 84%. The values were selected using the data available from intensive farms in Cuba where the range for survival goes from 60% to 84% depending on the farm.

Simulation results show that there is a 68.3% chance of obtaining yields higher than 9,000 kg/ha. Figure 17 shows the forecasting chart obtained in Crystal Ball (calculations based in ponds of 0.1 ha).

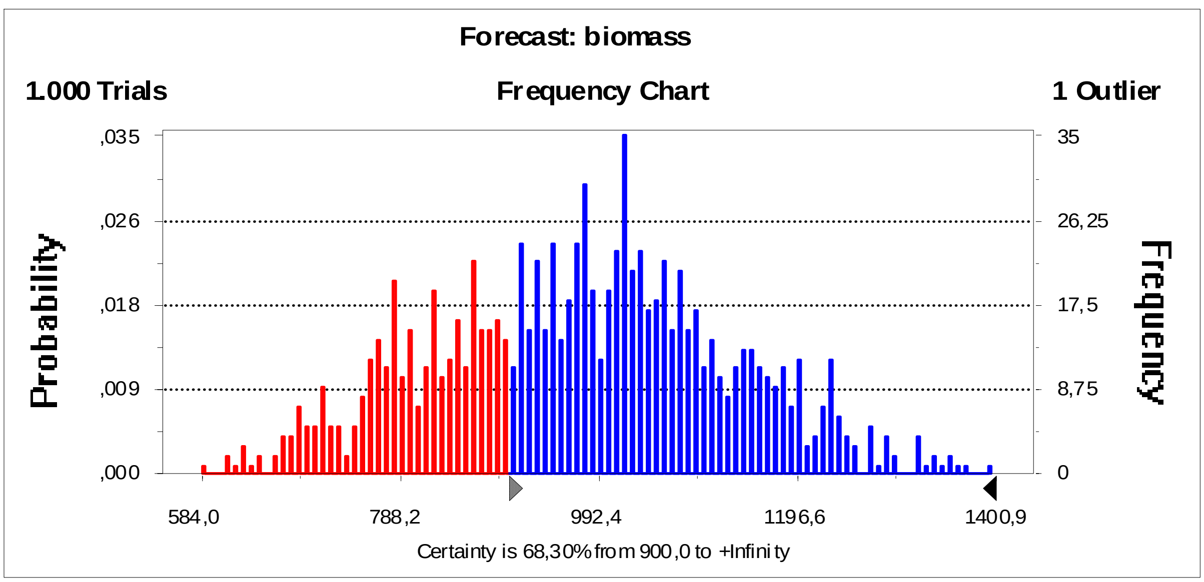


Figure 17: Forecasting chart for biomass within 240 days of farming.

(Area between arrows shows the certainty of obtaining yields higher than 9,000 kg/ha (Pond size 0.1 ha)).

According to the information above and previous information one obtained by running the simulation, a financial model can be created assuming the farm will have 10 ha available for intensive culture (10 ponds of 1 ha each), with an expected yield around 9-10 tons/ha and a frame of time for harvesting of 8 months (240 days).

4.4 Tilapia farming

For the tilapia farming biological and economic parameters were selected according to their importance in the farming process. The economics parameters utilized are those that are directly related with the farm production and can influence both quality and yields.

Biological parameters:
- Survival
- Growth equation coefficient
- Feed conversion ratio

Economics parameters:
- Fingerlings price
- Feed price
- Super phosphate price
- Urea price
- Cal price
- Electricity cost
- Fishing gear cost
- Fuel cost
- Investment

The probability distributions for the survival and growth equation coefficients were discussed in sections 4.2 and 4.3 so here the focus will be on the other parameters. For feed conversion ratio the probability distribution was chosen using data available from intensive culture farms. The feed conversion ratio achieved varies from farm to farm were values range between 2.0 and 2.7 kg feed per kg of biomass. An extreme value distribution was found as the probability distribution fit the available data. The extreme value distribution is commonly used to describe the largest values of a response over a period of time. In addition, extreme value distribution can describe extreme individual and simultaneous price movements for financial assets. There are two standard parameters for the extreme value distribution: mode and scale (Decsioneering 2000).

The mode is the most likely value for the variable. The scale parameter is a number greater than 0; the larger the scale value is, the greater the variance will be.

Figure 18 shows the probability distribution for the feed conversion parameter.

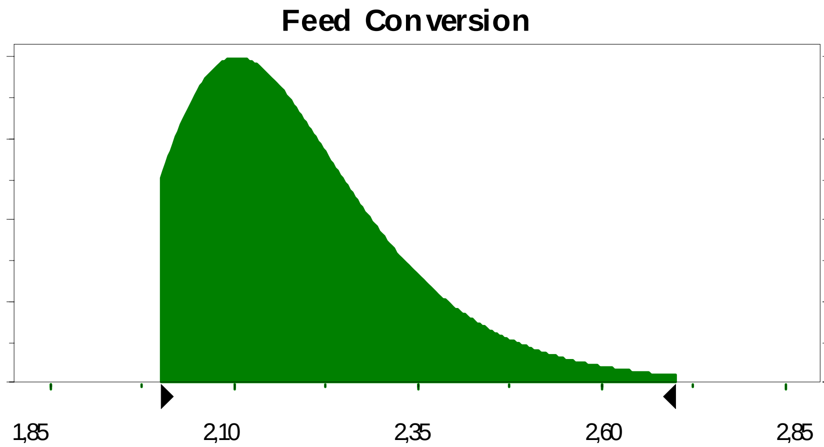


Figure 18: Extreme value distribution for the feed conversion ratio.

(Maximum value: 2.7, minimum value: 2 and mode value: 2.1 USD/thousand).

The minimum and maximum limits were selected from the available data on intensive farming in Cuba. The mode value is the value expected for the feed conversion ratio in the project.

Triangular distributions fit the cost data best, since normally the minimum, maximum and more likely values are well known for the products prices. The price for fingerlings will have similar behaviour because it depends in the same way on imported supplies that can affect the production cost

Figure 19 shows the triangular distributions for fingerlings. The most likely value corresponds to the current prices that INDIPES are paying for fingerlings. The fingerlings production cost has remained stable because the production is carried out by farms that belong to the INDIPES Company. Fingerlings are grown until they reach 10 g. We do not expect bigger than 10% variations in the cost except those related to the cost of the products acquired on international markets.

Figure 19: Triangular distribution for fingerlings price.

(Maximum value: 7.92 USD/thousand, minimum value: 6.48 USD/thousand and most likely value: 7.20 USD/thousand).

The feed used in intensive farms in Cuba is produced domestically. The current price is 360.00 USD/ton of fish meal. The availability and quality of feed can be affected for various reasons so sometimes we need to rely on international fish meal traders to obtain the feed needed. The maximum value in the feed price distribution corresponds to the average price in the Latin American market for fish meal according to the tilapia proteins requirement. Extreme value distribution was selected following the fishmeal prices behaviour according to data obtained from World Bank web page (World Bank 2004).

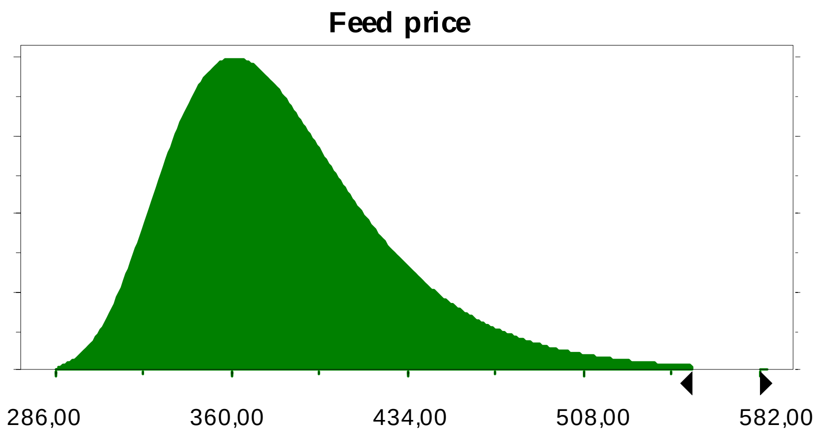


Figure 20: Extreme value distribution for feed price.

(Maximum value: 450 USD/ton, minimum value: 324 USD/ton and mean: 360 USD/ton).

Due to a lack of data for products associated with pond fertilisation such as Super-phosphate, Urea and Cal. It was decided to vary the price by ± 10% in each case around the most likely value for each parameter. The most likely value was selected using the current price INDIPES pays for these items today. The ponds are fertilized two times before stocking at a rate of 174 kg Urea/ha and 44 kg super phosphate/ha. In the case of cal 100 kg are needed per metric tons of fish.

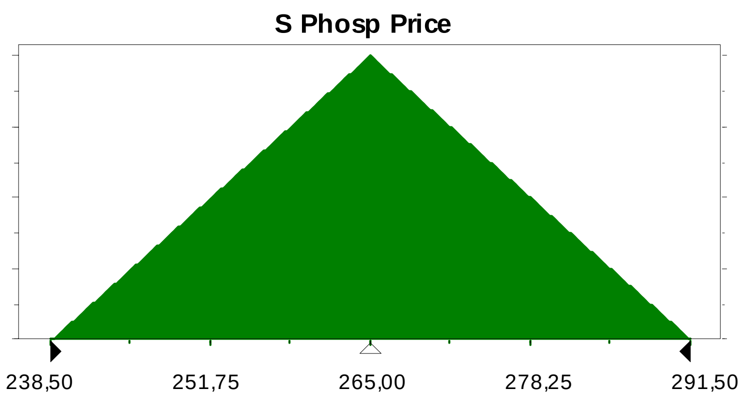


Figure 21: Triangular distribution for Super Phosphate price.

(Maximum value: 291.50 USD/ton, minimum value: 238.50 USD/ton and most Likely value: 265.00 USD/ton).

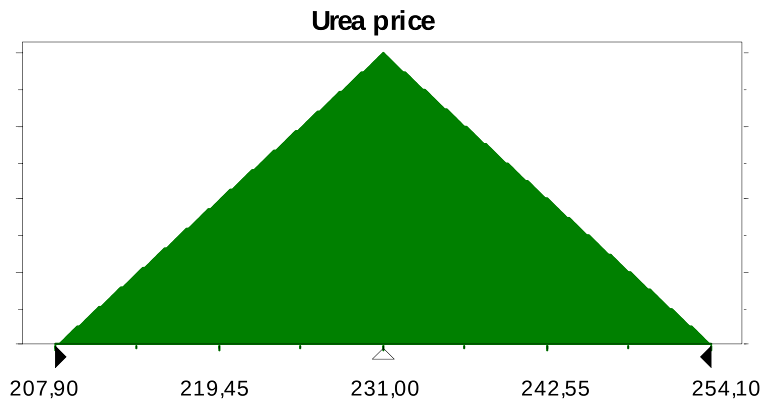


Figure 22: Triangular distribution for Urea price.

(Maximum value: 254.10 USD/ton, minimum value: 207.90 USD/ton and most likely value: 231.00 USD/ton).

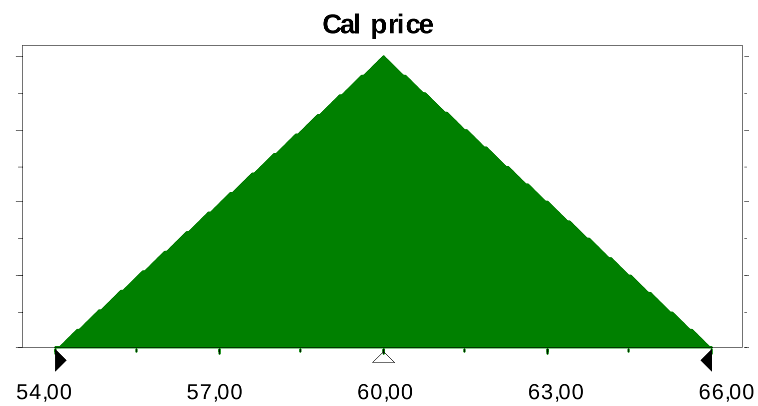


Figure 23: Triangular distribution for Cal price.

(Maximum value: 66 USD/ton, minimum value: 54.90 USD/ton and most likely value: 60 USD/ton).

The electricity in Cuba is produced using fuel-based thermoelectric plants so the electricity cost increases as the cost of fuel increases. Also harvest activity depends on transport that consumes fuel like tractors or trucks, in addition to the ice and harvesting gears. Fuel price movements from 1988 until 2004 were found to follow a normal distribution curve. Therefore, we decided to assign the same distribution to the cost for the fuel and electricity. The mean values were the current costs for these items, following the same standard deviation (9.04) as fuel distribution. The next figure shows the distribution probabilities for electricity and fuel costs. The actual cost of electricity in an intensive farm is 2.27 USD/ton of fish and the cost of diesel is 6.62 USD/ton of fish.

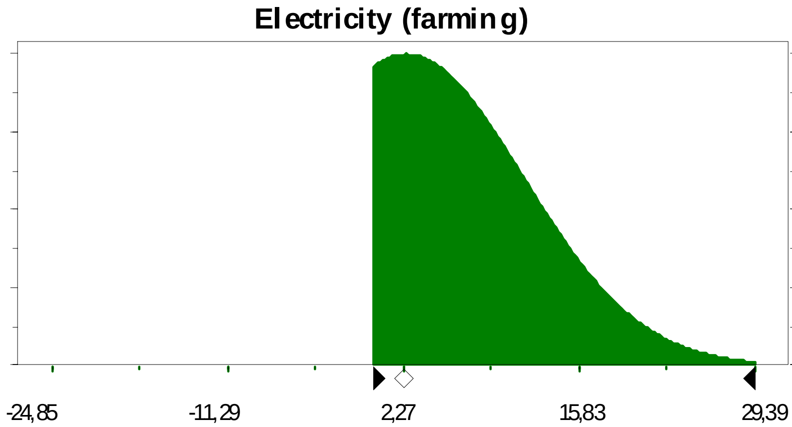


Figure 24: Normal distribution for electricity cost (farm).

(Mean value: 2.27 USD/ton of fish, standard deviation: 9.04).

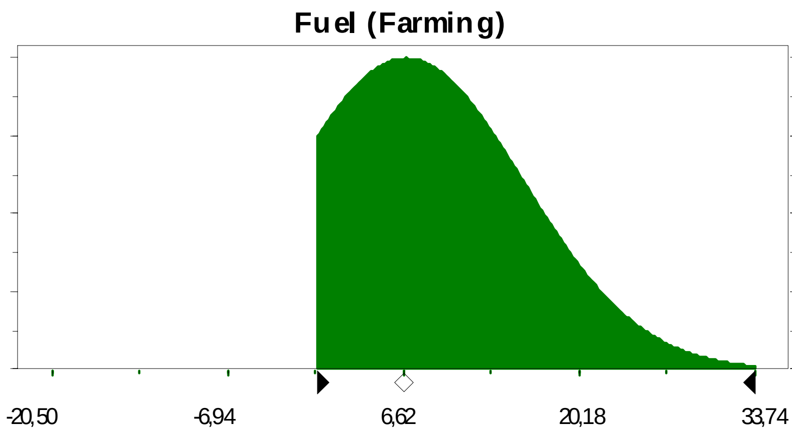


Figure 25: Normal distribution for fuel cost (farm).

(Mean value: 6.62 USD/ton fish, standard deviation: 9.04).

For harvesting gear a triangular distribution was selected using the current cost as a minimum value. It was assumed that the cost will increase by 100% in case we use other sources than are actually being used. The most likely value will be only 30% over the current cost. Fishing gear is generally acquired through governmental credits with the Republic of China, sometimes with preferential prices from Chinese companies. Figure 26 show the triangular distribution selected for the fishing gear cost parameter.

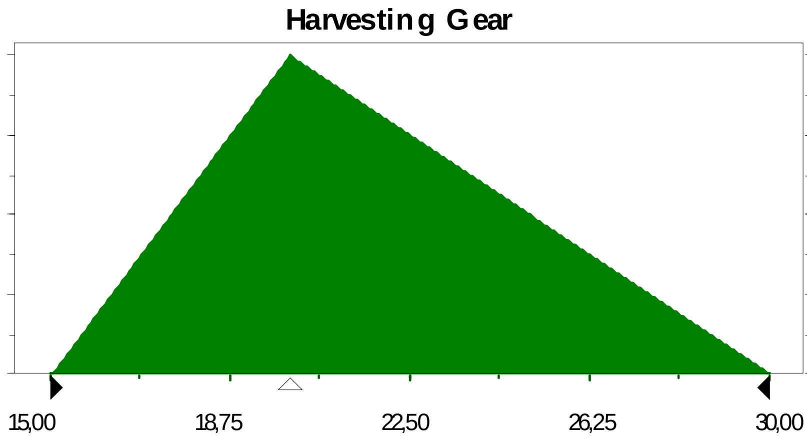


Figure 26: Triangular distribution for fishing gear cost.

(Maximum value: 30 USD/ton, minimum value: 15 USD/ton and most likely value: 20 USD/ton).

Investment in farming equipment is necessary for the survival of fish and water quality. For that reason we include paddlewheel aerators, flake ice plants and monitoring systems as necessary investments for each farm. The price for this equipment was obtained through an internet review for equipment suppliers and from information obtained through the INDIPES Company. Paddlewheel aerator prices range from 650 to 1,000 USD per unit with 700 USD per unit as the most common price for a middle range power system. We assume in this model that there are two aerators needed per ha (AquaInfo 2001). The triangular distribution for aerator prices is shows in Figure 27.

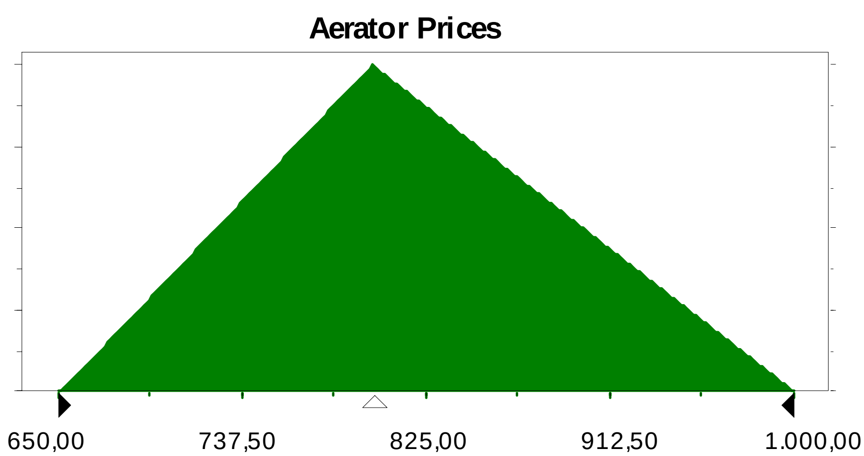


Figure 27: Triangular distribution for paddlewheel aerator prices.

(Maximum value: 1000 USD/unit, minimum value: 650 USD/unit and most likely value: 700 USD/unit).

The flake ice plants used currently in the intensive culture farms has a nominal capacity of production between 5-10 tons/24 hr. The ice plants are composed of an ice generator, a condensation unit, a metal structure and a storage silo. The prices for the 5 tons/24 hrs versions are around 45,000 USD/unit and for the 10 tons/24 hrs is around 80,000 USD/unit. So a triangular distribution for the ice plant prices was selected with a minimum value of 45,000 USD/unit and maximum of 90,000 USD/unit since we expect an increment in the price and a most likely value of 80,.000 USD/unit (Figure 28). The price for 10 tons/24 hrs ice plant was selected as the most likely value because this capacity covers all ice needed in the transportation of fish from the farm to the processing plant.

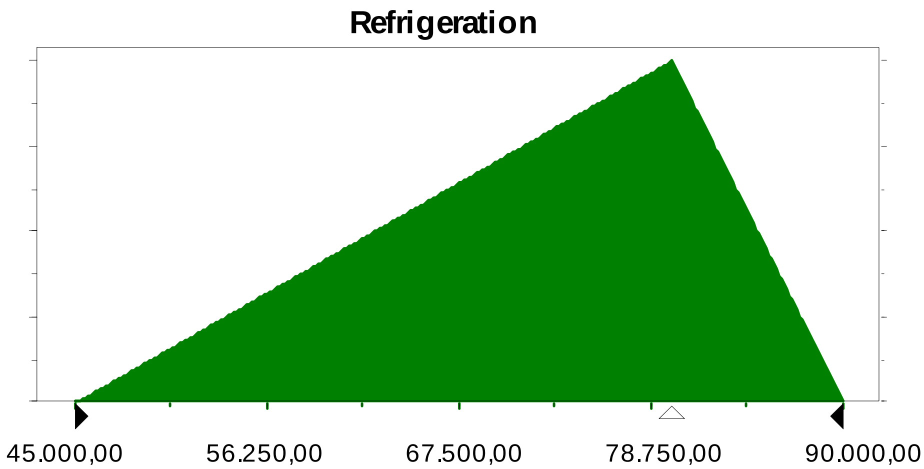


Figure 28: Triangular distribution for flake ice plant prices.

(Maximum value: 90,000 USD/unit, minimum value: 45,000 USD/unit and most likely value: 80,000 USD/unit).

For water quality and oxygen control an electronic monitoring system must be used where several parameters can be controlled through PC software. The prices vary according to the amount of measurement points in a range between 1,300 USD/unit and 5,000 USD/unit (Aquasales 2004). The most likely value was selected using the standard equipment with two measurement points and two different readings (1,800 USD/unit) because the size of the pond, no more than two readings points are needed (Figure 29).

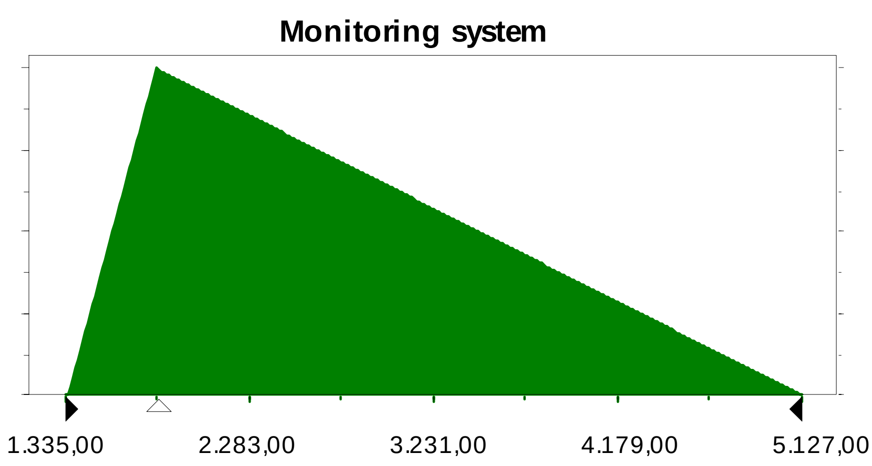


Figure 29: Triangular distribution for monitoring system prices.

(Maximum value: 5,000 USD/unit, minimum value1, 300 USD/unit and most likely value: 1,800 USD/unit).

4.5 Tilapia processing

For the processing area the parameters selected in order to assign a probability distribution were:

Processing parameter:

- Filleting yield

Economic parameters:

- Raw material cost
- Plastic bag prices
- Carton box prices
- Fixed cost
- Fillet prices
- Transport cost
- Water cost
- Electricity cost
- Maintenance cost

The parameters were selected mainly based on their importance in the efficiency of processing for example the filleting yield and its direct influence on the final production cost such as plastic bag, carton box, water costs, electricity costs and maintenance costs. Fixed costs are related mainly with administration costs and financial costs that are not directly related with the tilapia production.

For filleting yield a normal distribution was selected since we assumed that the yield can be normally distributed around the mean value of 3.46 whole fish/fillets between the minimum value of 3.0 whole fish/fillets and maximum value of 3.57 whole fish/fillets. The limit values reflect the range of real yield obtained at processing plants in Cuba. In the next figure we show the normal distribution for filleting yield (Figure 30).

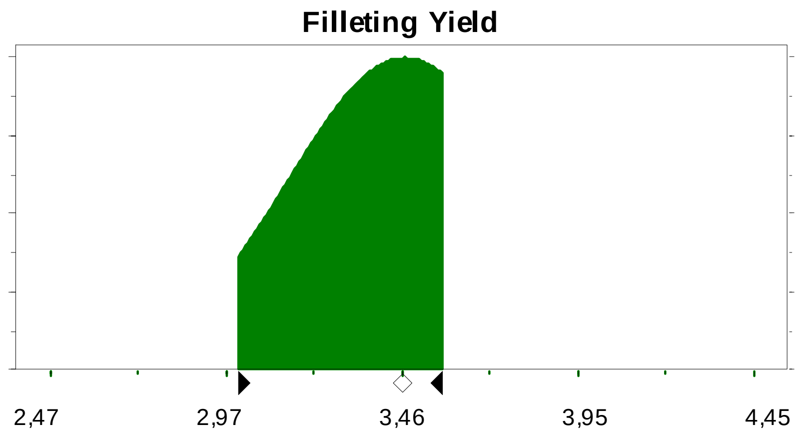


Figure 30: Normal distribution for filleting yield.

(Maximum value: 3.57, minimum values: 3.0 mean: 3.46).

In the case of materials for packing the fillets such as plastic bags and carton boxes we do not have the range of prices on the market for those products so we will select triangular distributions for both of them with a variation of ± 10% of the current prices that the INDIPES Company pays. Normally we use in case of export products materials supplied by overseas companies with commercial offices in Cuba and operative production with domestic suppliers in order to guarantee supplies and price stability. The next figures show the distributions for each case.

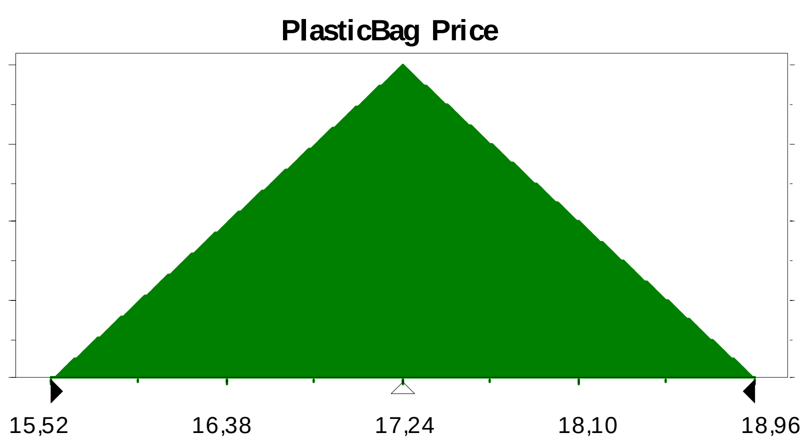


Figure 31: Triangular distribution for plastic bag prices.

(Maximum value: 18.96 USD/thousand, minimum value: 15.52 USD/thousand and most likely value: 17.24 USD/thousand).

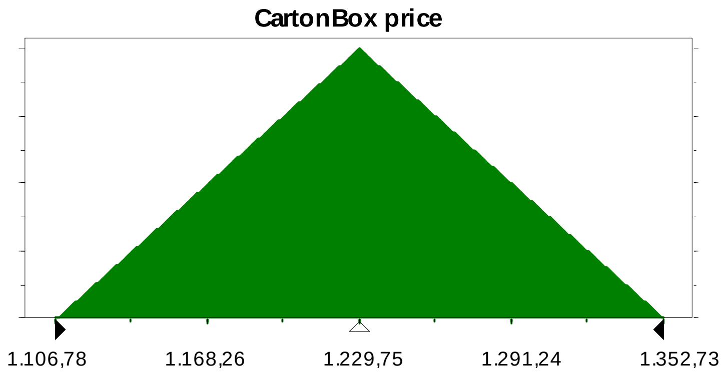


Figure 32: Triangular distribution for carton box prices.

(Maximum value: 1,352.73 USD/thousand, minimum value: 1,106.78USD/thousand and most likely value: 1,229.75 USD/thousand).

For the electricity and water costs (water is pumped with electricity) related with a fish processing plant we follow the same principle used to select the range for fuel and electricity costs. The mean value will be the current cost for those items and the standard deviation will be the same as for fuel price normal distribution (9.04). The next figures show the normal distribution for processing plant electricity costs and water costs.

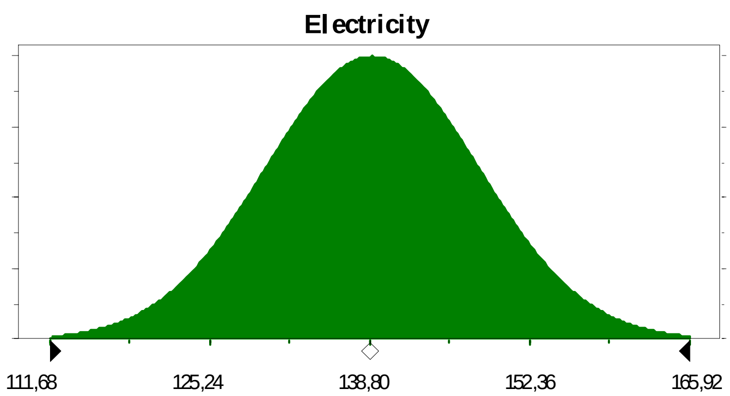


Figure 33: Normal distribution for electricity cost.

(Mean value: 138.80 USD/ton, standard deviation: 9.04).

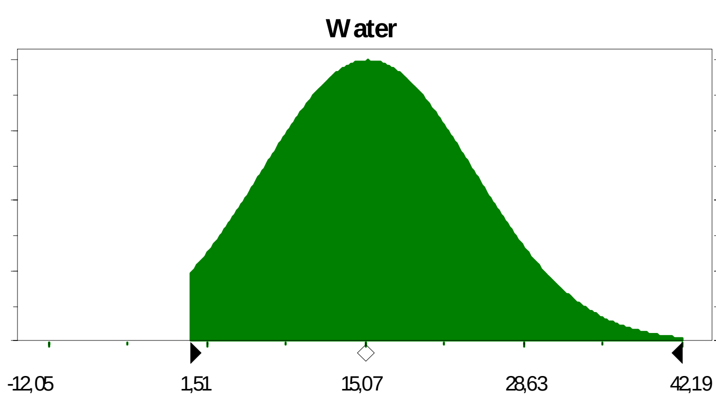


Figure 34: Normal distribution for water costs.

(Mean value: 15.07 USD/ton, standard deviation: 9.04).

In the case of auxiliary materials, such as disinfection chemicals and cleaning products, an increment of 20 % over the current cost was selected and the most likely value was a 10 % increment over the current cost. In the figure we show the triangular distribution for this cost. We do not have available the range of prices for chemicals and disinfecting products, however, we expect increments on prices in the range we selected since we are buying those products on the international market according to Cuban and EU regulations approved for those products. Based on our experiences prices increase on this scale from one year to another.

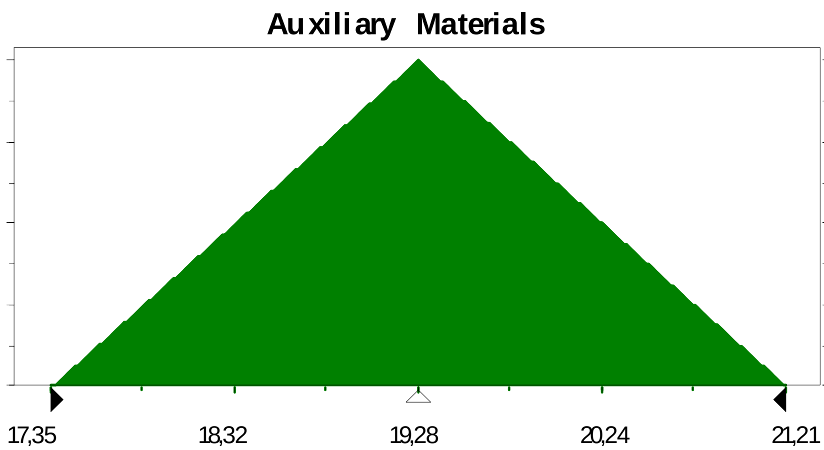


Figure 35: Triangular distribution for auxiliary materials cost.

(Maximum value: 21 USD/ton, minimum value: 17 USD/ton and most likely value: 19 USD/ton).

The maintenance cost is going to increase over time since equipment becomes old and needs continuous maintenance and spare parts because the maintenance and reparation is almost always carried out when a failure occurs, not when the cost for maintenance has been programmed to increase. For that reason we assume the cost for maintenance will increase 100% over the current value and the most likely value will be 60% over the current value. The next figure shows the triangular distribution for maintenance cost.

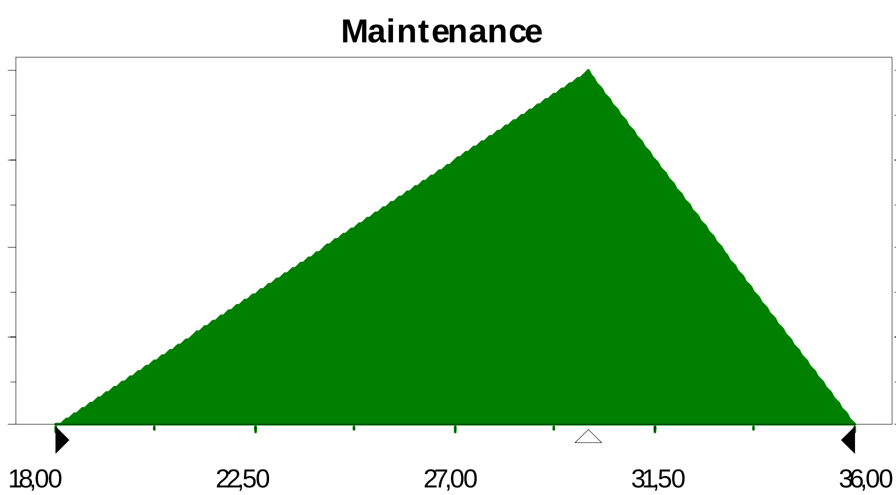


Figure 36: Triangular distribution for maintenance cost.

(Maximum value: 36 USD/ton, minimum value: 18 USD/ton and most likely value: 30 USD/ton).

The refrigerated transport company that carried all the fisheries products around the country has a tariff that varies according to the distance from the processing plant to the cold storage in the port. The cost ranges between 40 USD/ton and 75 USD/ton. Since the most important processing plants are in the central and eastern provinces we assumed the most likely value was 70% over the minimum value. Figure 37 shows the triangular distribution for the transport cost.

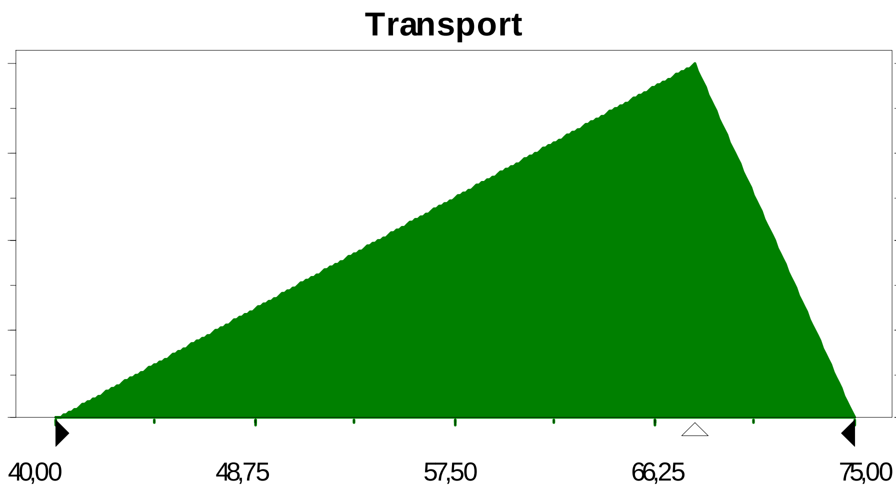


Figure 37: Triangular distribution for transport cost.

(Maximum value: 40 USD/ton, minimum value: 75 USD/ton and most likely value: 68 USD/ton).

Historical FOB fillet prices for the USA and the EU were used to in order to determine the most suitable probability distribution for the fillet prices through the Crystal Ball capacity to fit the distribution to existing data. We found that fillet prices follow in both cases an extreme value distribution. Prices per kg in the USA are lower than in the EU so we decided to use the USA range of prices for our project as a precautionary approach.

We will introduce uncertainty in the sales prices assigned to independent extreme value distribution for the first five years. Per se the distributions are the same for each year so we only show the distribution for the first year in the next figure.

Figure 38: Extreme value distribution for sales price.

(Maximum value: 4.7 TUSD/ton, minimum value: 2.7 TUSD/ton and mode value: 4.2 TUSD/ton).

Because of a lack of data and uncertainty around the fixed costs data related with farming and processing production of tilapia in Cuba, we decided to use uniform distribution in order to describe this parameter in the model. Roughly we calculated a minimum value of 100,000 USD for the fixed costs and assigned a maximum value of 1,000,000 USD. Any value between both extreme has the same probability of occurring. The uniform distribution for the fixed costs is shown in the next figure. Fixed costs include administration costs, financial costs and other costs not directly related to the production.

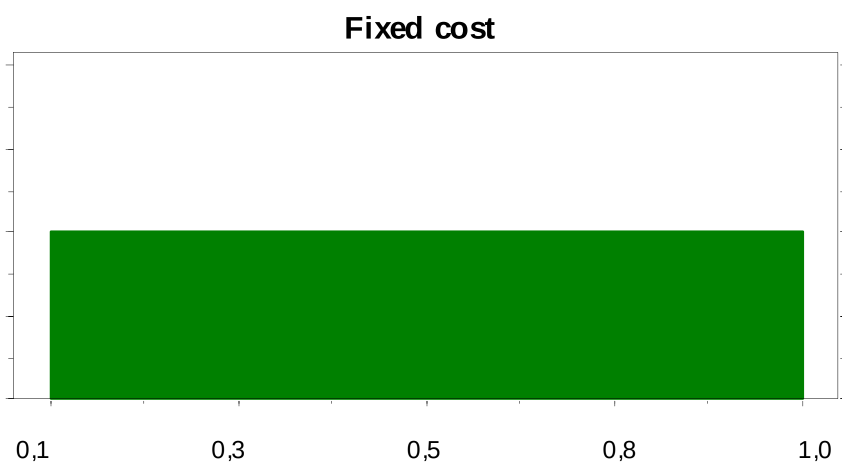


Figure 39: Uniform distribution for fixed costs.

(Maximum value: 1,000,000.00 USD, minimum value: 100,000.00 USD).

In this chapter we have discussed the parameters selected as assumptions and the distribution of probabilities associated with each of them selected according to the available data and information found on the Internet. In this way we introduce uncertainty in the model and we are capable of analysing several scenarios through the Monte Carlo simulation. In the next chapter we will present the results obtained after ten thousand iterations (10,000) simulation runs.

5 SIMULATION RESULTS

In this chapter the model outcome is going to be analysed obtained from the Monte Carlo simulation (10,000 iterations) in a frame time of 10 years focusing on production, costs, revenues, NPV forecasting chart, financial ratios chart and sensitivity chart. The result from the analysis will give the information needed to determine whether the project is profitable or not.

5.1 Operation, cash flows and investment analysis

Fillets production per year depends on how many cycles of production are carried out on the farm. The production on the farm must be double every two years since the eight month cycle allows two harvesting periods. Through simulation we found the fillets production follow a normal distribution (Figures 37 and 38) around the mean value of 21.4 tons/year with a minimum value of 15 tons/year and a maximum of 28 tons/year in even years. In odd years the mean value is 42.8 tons/year with a range of possible outcomes from 30 tons/year to 56 tons/year. Those variations are conditioned to the uncertainty introduced in the model such as fillet yield, growth coefficient and survival.

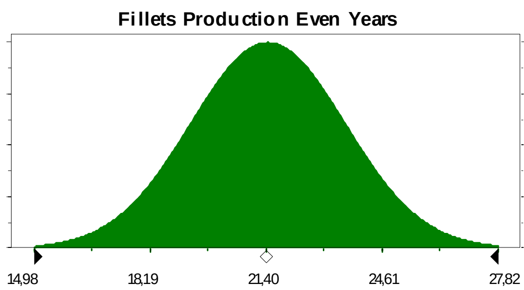


Figure 40: Fillet production in even years.

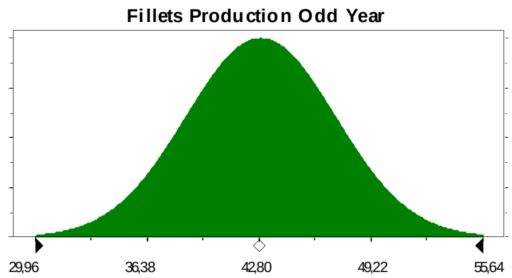


Figure 41: Fillet production in odd years.

Variable cost follows a normal distribution with a mean value of 3.68 USD/kg of fillets. Under very favourable conditions the lowest cost is 2.92 USD/kg on other hand in the worst case the variable cost can increase to 4.44 USD/kg making it impossible to obtain profits. Note the minimal difference between the mode value on the total sales prices chart (3.90 USD/kg) and the mean value on the variable cost chart.

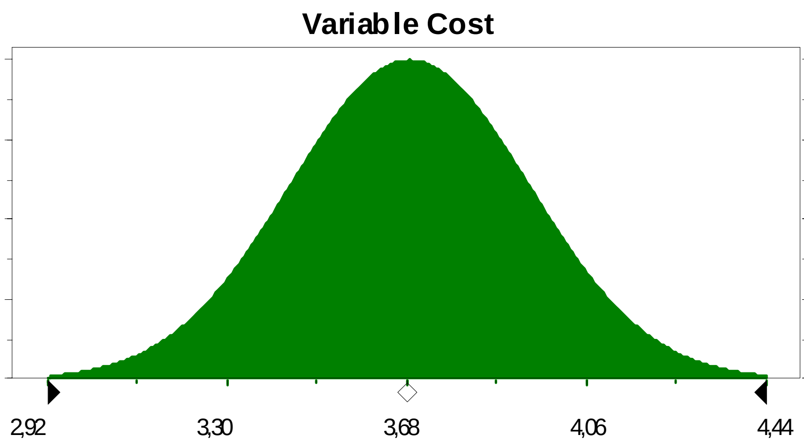


Figure 42: Variable cost distribution.

Fixed cost follows a uniform distribution with an average value of 560,000 USD/year. The minimum value obtained in the simulation was 90,000 USD/year and the maximum was 1,000,000 USD/year.

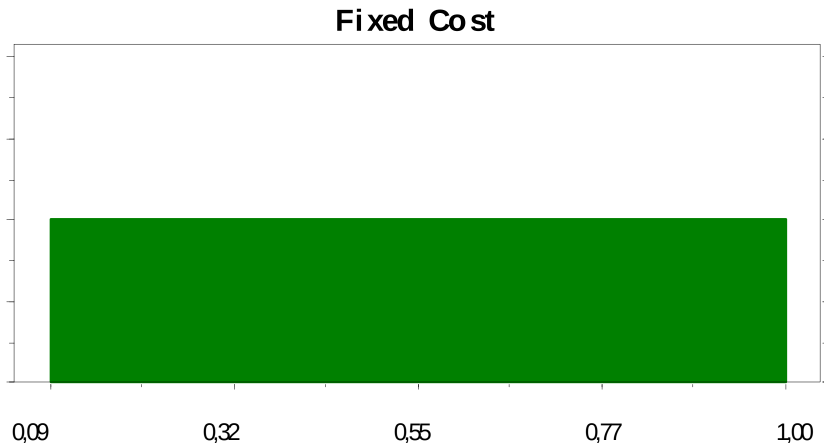


Figure 43: Fixed cost distribution.

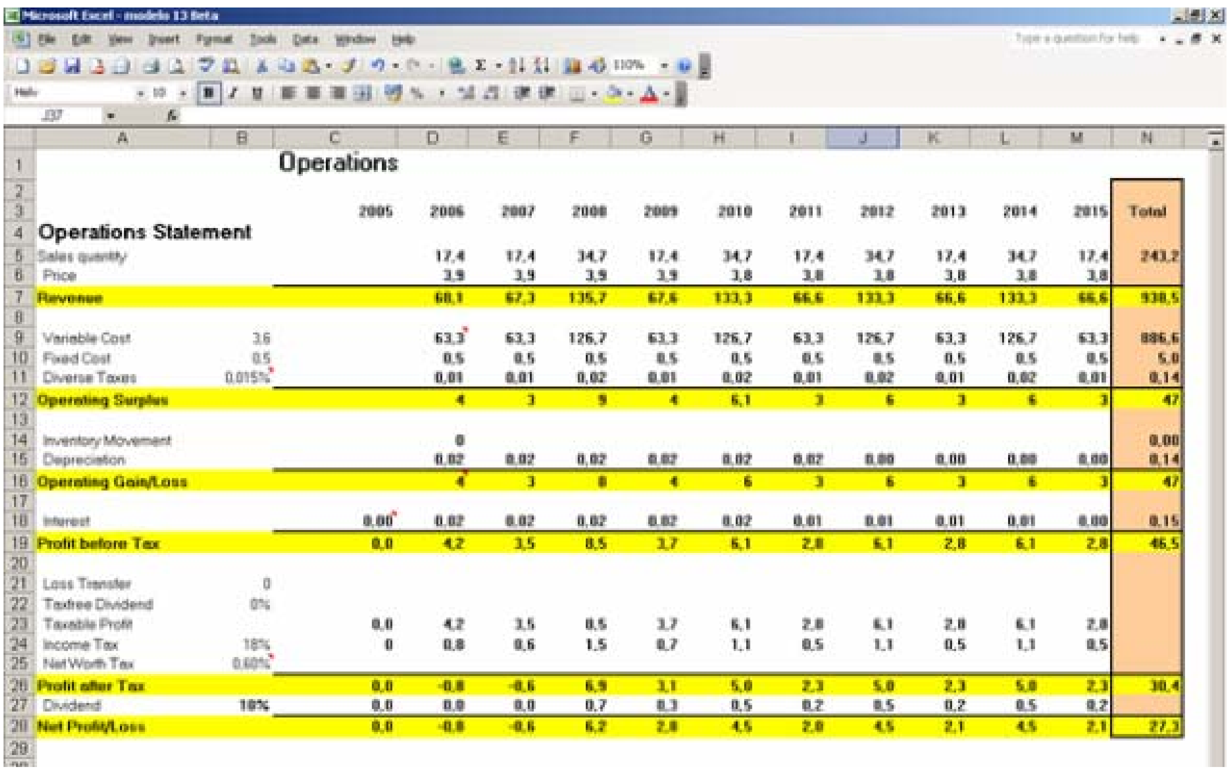
Sale prices show extreme value distribution shape with a mode value of 3.90 USD /kg of fillets and the maximum and minimum values range between 3.76 USD/kg and 3.95 USD/kg respectively (Figure 44). In this specific case one can find the highest prices over 3.90 USD/kg corresponding to the third year were the production is double, increasing the revenue for that year. However in the fifth year we have double production but the sales prices are the lowest in the five years, dropping significantly the revenues from operations despite high production (Figure 45).

Figure 44: Total sales prices distribution.

15	Operations:			2006	2007	2008	2009	2010	
16	Sales Quantity	100%		23,9	23,9	47,8	23,9	47,8	ton/year
17	Sales Price	100%		3,92	3,88	3,91	3,89	3,84	KUSD/ton
18	Variable Cost	100%	3,4	KUSD/ton					
19	Fixed Cost	100%	0,5	MUSD/year					
20	Inventory Build-up								
21	Debtors	25%	of turnover						
22	Creditors	10%	of variable cost						
23	Dividend	10%	of profit						
24									

Figure 45: Production and sales prices values per year.

In Figure 46 it can be seen the result of 10 years of project operations. After the third year we have an increase in revenues from 67.3 million USD to 135.68 million USD since the production has double cycle. Every odd year, however, the price drops after the fifth year affect the revenues in the next five years since they have the same value assuming that price remains the same. In operation surplus we note that the maximum value is nine million USD in the third and dropping in the next years as low as three million in even years and six million in odd years. At this point we can understand the importance of the sales price since a reduction in the sales prices of around 10 USD/kg leads to losses of 3 million USD before taxes in odd years. In net profits we have losses until the third year when 6.2 million USD in profits are achieved, keeping the revenues around 4.5 million in odd years and 2.8 million in even years. Again we have a margin of 1.7 million between the third year and fifth year after taxes because prices drop.



Operations

Operations Statement		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Sales quantity			17,4	17,4	34,7	17,4	34,7	17,4	34,7	17,4	34,7	17,4	243,2
Price			3,9	3,9	3,9	3,9	3,8	3,8	3,8	3,8	3,8	3,8	
Revenue			68,1	67,3	135,7	67,6	133,3	66,6	133,3	66,6	133,3	66,6	938,5
Variable Cost	3,6		63,3	63,3	126,7	63,3	126,7	63,3	126,7	63,3	126,7	63,3	886,6
Fixed Cost	0,5		0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	5,0
Diverse Taxes	0,015%		0,01	0,01	0,02	0,01	0,02	0,01	0,02	0,01	0,02	0,01	0,14
Operating Surplus			4	3	9	4	6,1	3	6	3	6	3	47
Inventory Movement			0										0,00
Depreciation			0,02	0,02	0,02	0,02	0,02	0,02	0,00	0,00	0,00	0,00	0,14
Operating Gain/Loss			4	3	8	4	6	3	6	3	6	3	47
Interest		0,00	0,02	0,02	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,00	0,15
Profit before Tax		0,0	4,2	3,5	8,5	3,7	6,1	2,8	6,1	2,8	6,1	2,8	46,5
Loss Transfer	0												
Taxfree Dividend	0%												
Taxable Profit		0,0	4,2	3,5	8,5	3,7	6,1	2,8	6,1	2,8	6,1	2,8	
Income Tax	18%	0	0,8	0,6	1,5	0,7	1,1	0,5	1,1	0,5	1,1	0,5	
Net Worth Tax	0,60%												
Profit after Tax		0,0	-0,8	-0,6	6,9	3,1	5,0	2,3	5,0	2,3	5,0	2,3	30,4
Dividend	10%	0,0	0,0	0,0	0,7	0,3	0,5	0,2	0,5	0,2	0,5	0,2	
Net Profit/Loss		0,0	-0,8	-0,6	6,2	2,8	4,5	2,0	4,5	2,1	4,5	2,1	27,3

Figure 46: Project operations in ten years.

In Figure 47 the cash flow movement can be seen during the ten years. Despite negative net cash flow after even years at the end of the last year we have positive cash movement. This tells us the project is capable of producing incremental cash flows through the operation sales and could become better if the sales prices increase and production cost decreases. Liquidity in the project allows us to re-invest in the farm and in the processing plant in order to increase the yield and production capacity.

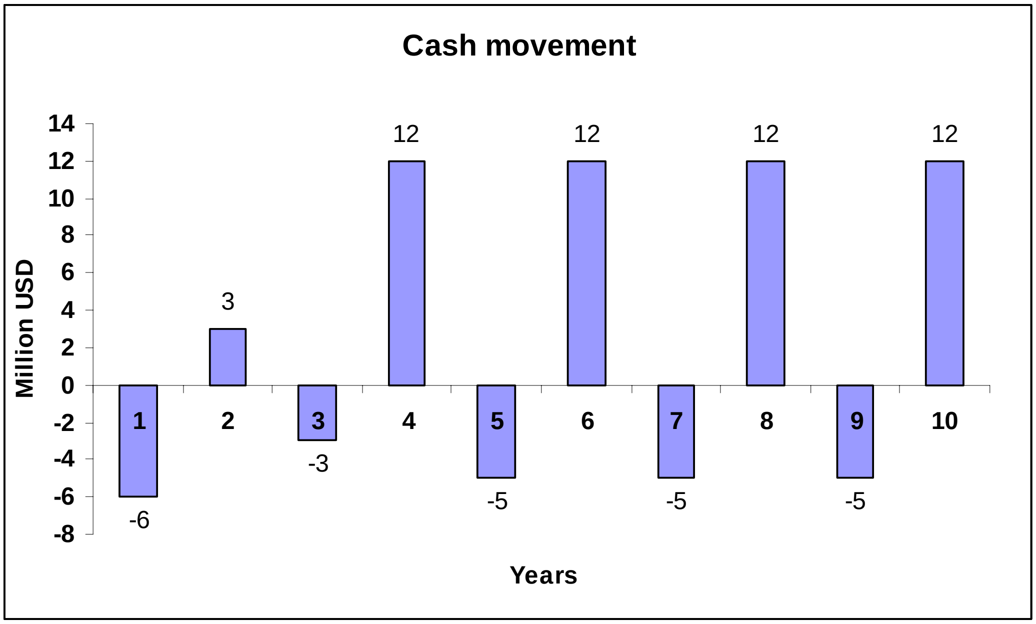
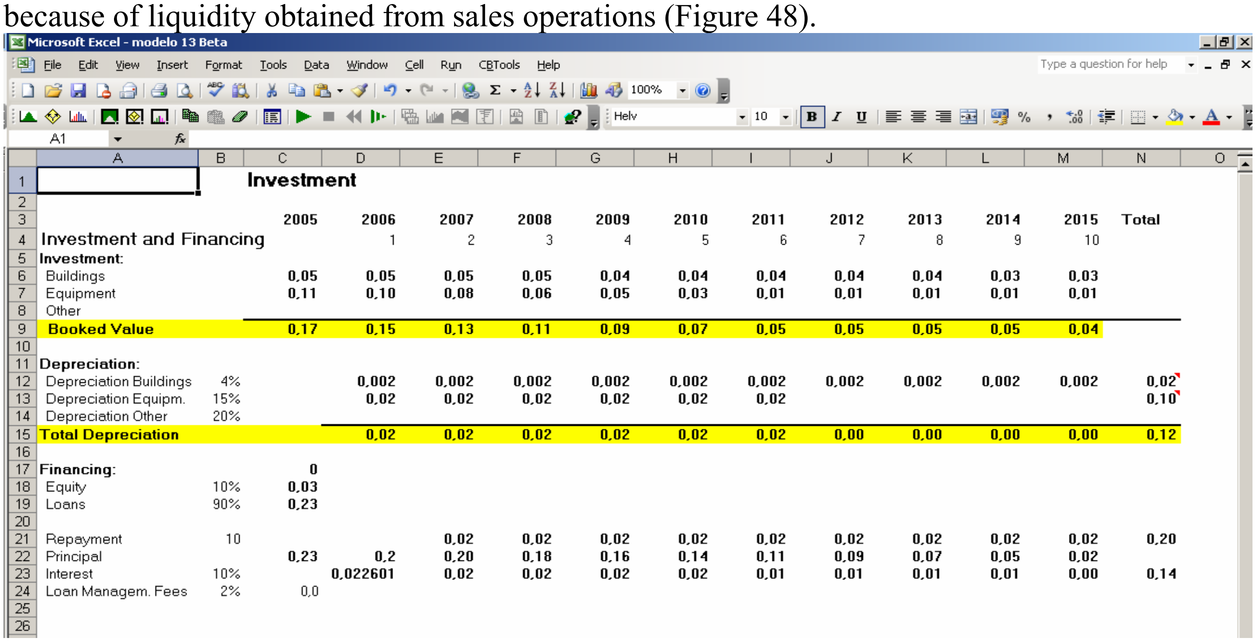


Figure 47: Project cash flows in ten years.

In the model it is assumed that depreciation of buildings is 4% in 15 years and 15% for equipment until it is 10% of its initial value. Since the intensive farms and processing farms do not have capital to develop a project like this, 90% of financing will come from loans and rest from equity, in this case INDIPES Company. Since liquid assets of the company will be increased after the sixth year, part of revenues can be used to pay the principal from the loans and reduce interest payment over a longer period of time. Further investment can be done reducing the percent of bank loans involved in the project increasing the percent of equity because of liquidity obtained from sales operations (Figure 48).



Investment

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Investment and Financing			1	2	3	4	5	6	7	8	9	10	
Investment:													
Buildings		0,05	0,05	0,05	0,05	0,04	0,04	0,04	0,04	0,04	0,03	0,03	
Equipment		0,11	0,10	0,08	0,06	0,05	0,03	0,01	0,01	0,01	0,01	0,01	
Other													
Booked Value		0,17	0,15	0,13	0,11	0,09	0,07	0,05	0,05	0,05	0,05	0,04	
Depreciation:													
Depreciation Buildings	4%		0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,02
Depreciation Equipm.	15%		0,02	0,02	0,02	0,02	0,02	0,02					0,10
Depreciation Other	20%												
Total Depreciation			0,02	0,02	0,02	0,02	0,02	0,02	0,00	0,00	0,00	0,00	0,12
Financing:		0											
Equity	10%	0,03											
Loans	90%	0,23											
Repayment	10			0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,20
Principal		0,23	0,2	0,20	0,18	0,16	0,14	0,11	0,09	0,07	0,05	0,02	
Interest	10%		0,022601	0,02	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,00	0,14
Loan Managem. Fees	2%	0,0											

Figure 48: Investment, depreciation and financing in 10 years.

5.2 NPV forecasting chart

After running Monte Carlo simulation (10,000 iterations) using Crystal Ball® over the biological and financial model we obtain the forecast chart for NPV corresponding to each year selected in order to evaluate the project's profitability. The first thing we note is that NPV shows a well defined normal distribution shape (Figure 49). With the objective to know the certainty of obtaining positives values of NPV we select for each forecast the values of zero as the minimum limit selecting only positive values in the graph between arrows. Figure 49 shows the NPV forecast after 10 years was 63.25% probability that positive outcome will be reached.

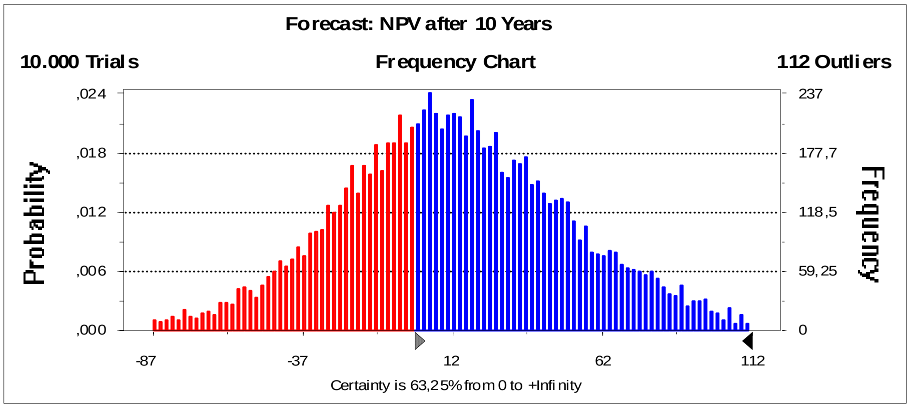


Figure 49: Forecast and certainty of obtaining positives values of NPV after 10 years. (Project projection obtained from Monte Carlo simulation (10,000 iterations)).

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Figure 50 shows that only in half of the 10,000 possible scenarios is there a chance of obtaining values of IRR between 0% and 200% after ten years.

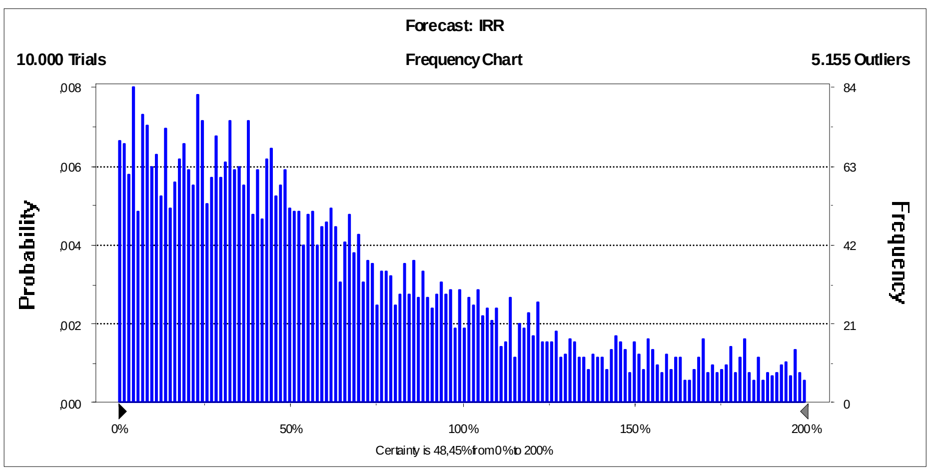

Figure 50: Forecast and certainty of obtaining IRR values from 0%-200% after 10 years.

Table 8 give us the result for the same analysis for each forecast chart obtained from simulation in the model.

Table 8: Results from Monte Carlo simulation.

NPV Forecast	Certainty of obtaining positives NPV (%)	NPV value Mean
After 1 year	14.00	-6
After 2 years	35.60	-3
After 3 years	36.32	-5
After 4 years	53.78	3
After 5 years	49.99	1
After 6 years	59.63	7
After 7 years	56.54	6
After 8 years	61.79	11
After 9 years	59.80	10
After 10 years	63.25	13

A certainty of obtaining more than 65% of NPV positive values is not achieved after 10 years from the beginning of the project. At first sight this can be explained by the fact that export prices to the USA were used that are relatively lower than the EU market prices.

5.3 Financial ratios

In this chapter we are going to analyse the financial ratios obtained from the project. To calculate the ratios we will use the average of the random annual sales prices used to run the Monte Carlo simulation. The rest of the parameters have the initial setup values before simulations are run. It must be kept in mind that in each iteration run in the simulation a different financial ratios chart is obtained, in this case we are analysing only one case out of 10,000 possible outcomes from the simulation iterations.

Operating profit ratio (Figure 51) relates revenue from operation (fillets sales) with production cost without taking into consideration taxes, interest and depreciation cost. Analysing the chart we see operations profits drop in fifth year from 0.23 USD per dollar of sales to 0.14 USD per dollar of sales because in the fifth year the sale price drops from 3.9 TUSD/ton to 3.8 TUSD/ton showing the how sensitive the project is to sales price.

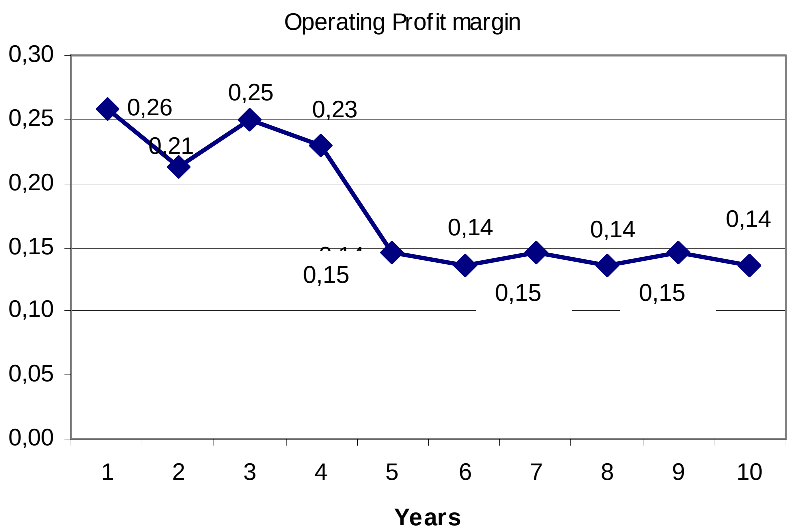

Figure 51: Operating profit margin ratio.

The net profit margin ratio relates revenues with the total cost so it represents the profits from sales after all cost has been subtracted. Analysing the chart we find that in the first two years we can expect losses. However, from the third year the project obtains profits of around 0.18 USD per dollar of sales since this year the production is double cycled and dropping again to 0.10 -0.11 USD per sales of dollar of sales because of drops in market prices in the fifth year from 3.9 TUSD/ton to 3.8 TUSD/ton (Figure 52).

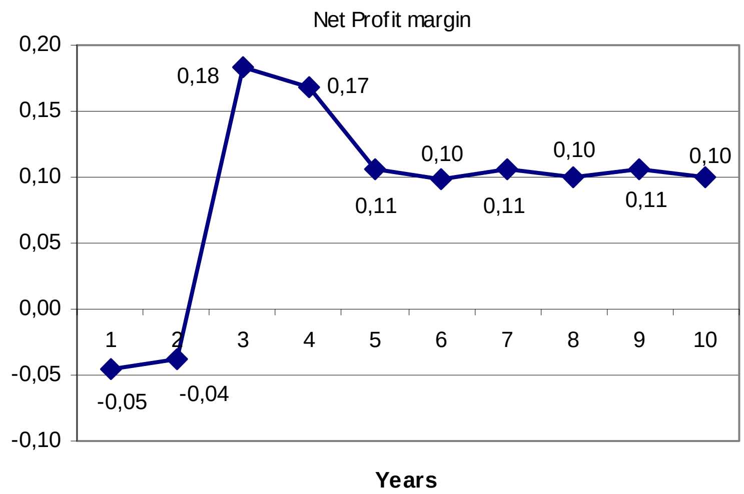

Figure 52: Net profit margin ratio.

Through net current ratio analysis we can conclude that the current liabilities can be well covered by the current assets since the beginning of the project. In the first year the assets values are1.52 times the liabilities values, at the end of the tenth year assets values are 5.6 times the liabilities values. The higher ratio means the higher project liquidity however this can also suggest that funds could be kept as cash and being used as productively as possible (Figure53).

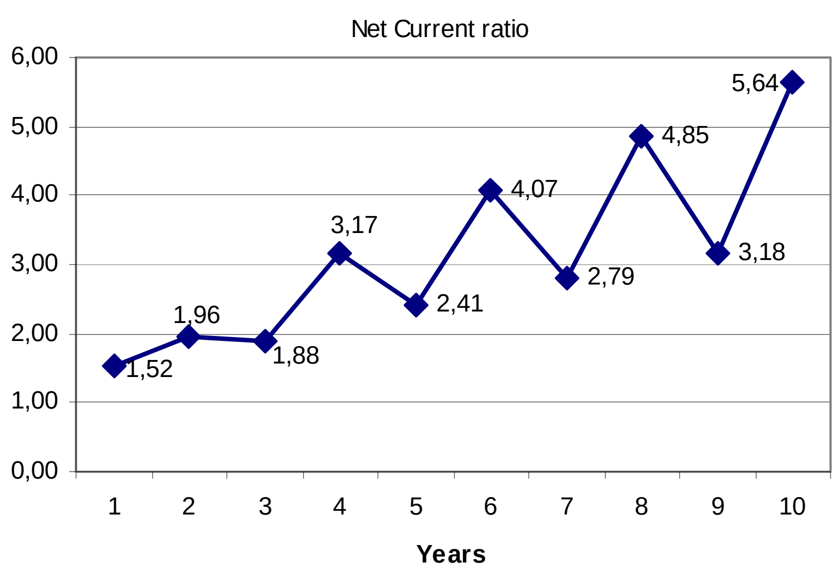

Figure 53: Net profit current ratio.

5.4 Sensitivity chart

Figure 54 shows the sensitivity charts for NPV after 10 years. Only the parameters which have the largest influence on NPV are shown.

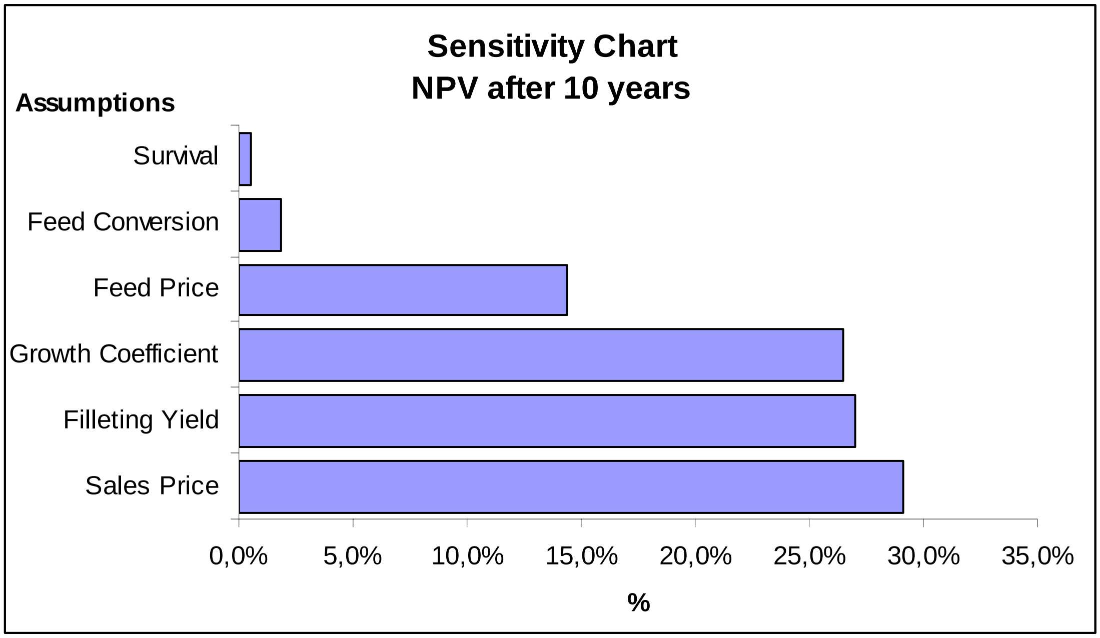

Figure 54: Results from sensitivity analysis of assumptions over NPV values.

This project is highly sensitive to sales prices with 29.1% (combined) of the variance. The price cannot be influenced since they respond to market trends limiting for better prices over the break point sales price. The same problem is evident with feed price, which makes up 14.1% of the total variance. However, other parameters may be controlled such as the growth coefficient (26.5%), filleting yield (27%), feed conversion (1.8%) and survival (0.5%). Other parameters have an insignificant influence on the NPV.

Feed conversion depends on the quality of feed but often feed containing higher values of protein are more expensive. Adequate feed must be selected that covers the tilapia requirements at competitive prices and at the same time reduces the feed conversion ratio as a way to reduce the cost and increase the likelihood of obtaining profits from tilapia production. On the other hand, improving the feed quality will contribute to increasing the survival parameter, which has an influence on the project.

The growth coefficient is associated with the culture and how it is carried out. Use of super males or sex reversed culture will increase the yield per pond since the growth rate is higher than males-females mixed culture obtaining higher average size in the harvest time. Despite the fact that tilapia is resistant to disease, disease control will help to achieve good results in intensive culture. The feeding parameters and frequency need to be observed to guarantee the highest quality. The yield of fillet processing depends on both fish size and workers skill. Trained personnel and proper knives for processing will increase the yield. On the other hand, the size of the fish is in many cases related with better filleting yields since the fillet usage portions are bigger and at the same time it is easier filleting bigger sizes than smaller ones. Using filleting machines could be another solution but that will be associated with higher expenses and will increase the processing variable cost.

In general, good management of the farm will guaranteed that the project can be carried out. Survival influence is not as important as the previous parameters; however obtaining higher survival in the culture obviously will increase the yield of the farm. By controlling natural predators, diseases and good quality feeding, the survival can be improved which will result in higher yields per ha.

In order to give an idea of how changes in parameters that have significant influence over NPV can improve the project probability, a new simulation was run but the characteristics filleting yield , growth coefficient and feed conversion were changed making over all process more efficient. Originally the worst value for filleting yield was 3.57 and for this simulation was set at 3.4 because we are assuming the tilapia sizes will be bigger and the worker skill better. For the growth coefficient in this case we will follow a narrow triangular distribution compared with the original one, keeping the current most likely value and maximum value. For feed conversion we also made a narrow distribution assuming the quality of feed is improved with higher levels of proteins and culture based on only male tilapia with fast growing and better feed utilization. The original maximum value for feed conversion was 2.7 and for this simulation was setup on 2.2. Figure 55 shows the new distribution setup for feed conversion, growth coefficient and filleting yield.

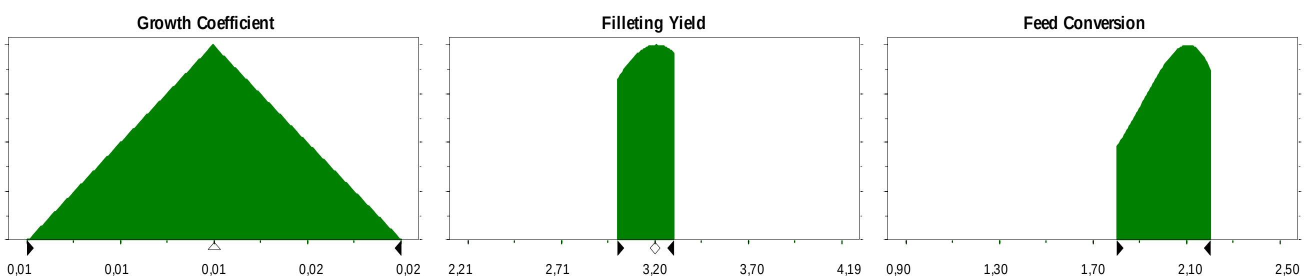

Figure 55: Distribution for improved growth coefficient, filleting yield and feed conversion.

After the Monte Carlo simulation (10,000 iterations) using this set up we obtain 83% certainty of obtaining positive values of NPV after ten years (Figure 56).

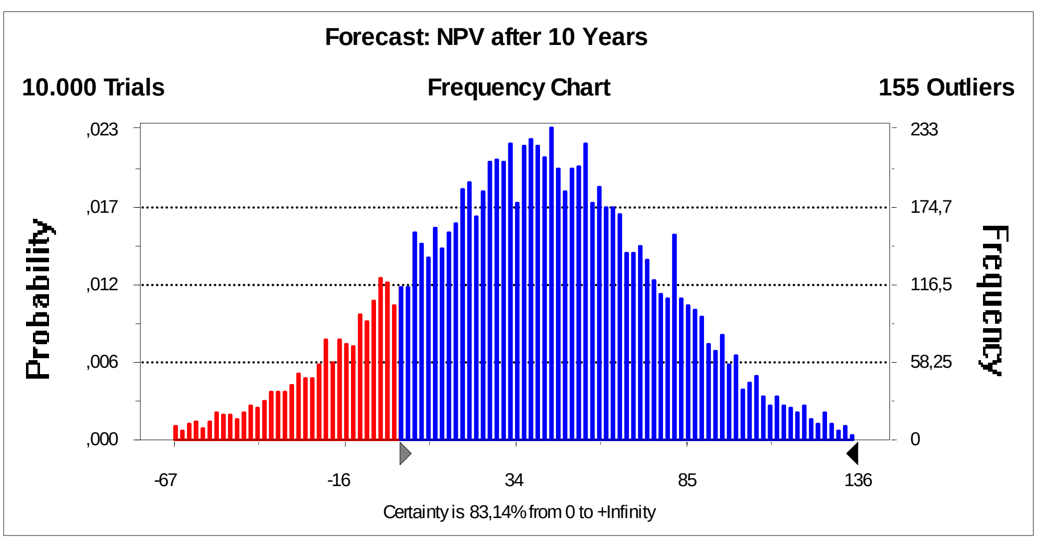

Figure 56: NPV forecast for improved growth coefficient, filleting yield and feed conversion.

The project's chances of being profitable have increased from 63% to 83% after ten years. This has been achieved by optimising parameters that have significant influence over NPV but at the same time are milestones in farming and processing areas. In the same way decreasing efficiency will reduce the chances of success.

6 CONCLUSIONS

After analysing the NPV forecasts, the sensitivity chart and several financial ratios obtained with the setting selected for each parameter we can conclude that:

After 10 years we only have a 63% chance of obtaining positive values of NPV. This does not meet our requirement of obtaining certainty equal or higher than 65% implying a significant risk in the project's implementation. The project is highly sensitive to sales prices (29% combined), filleting yield (27%), growth coefficient (26%), feed price, feed conversion and survival. This means that both farming and processing has important areas that need to be controlled carefully in order to obtain success. The net profits after taxes are low, only 0.10-0.17 USD per dollar of sales, this value can be increased by the price but needs products of high quality since the competition with Asian supplier will be hard. The cash flows after 10 years show positive values that can be used to increase the capacity and quality of tilapia production.

The certainty of obtaining higher values of NPV can be increased considering prices in the European market are higher than in the USA. However, only obtaining high fillet prices will not guarantee project success since the production depends on other important parameters related with farming and also with the quality at the processing stage. Applying correctly the technology for tilapia intensive farm using super males or sex reversed tilapia, combined with good feed, will guarantee high quality large-sized tilapia with a higher average harvesting weight that will allow the processing plant to achieve higher yields.

It is sustained that unless the parameters that have important influence over the project can be controlled carefully and all the areas such as the farm and processing plant operate with higher efficiency, implementing a project like the one we are discussing here is likely to be unprofitable because any drop in operation efficiency in both farming and processing will lead to the failure of the project. Also the market prices for the product need to be followed closely in order to know how the price trend will change in the future in order to be able to take the right actions and avoid losses.

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