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ECONOMIC VIABILITY OF SMALL SCALE SHRIMP (*Penaeus monodon*) FARMING IN THE NORTH-WESTERN PROVINCE OF SRI LANKA

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ABSTRACT

Shrimp export is the second most valuable export of fish and fishery products of Sri Lanka and it was 8% of during 2013. Among many commercial aquaculture initiatives so far, shrimp (*P. monodon)* farming has been the most lucrative, but the business is subject to high risk and uncertainties since it started in the mid-1980s. The present study evaluates the profitability and risks associated with semi intensive small scale shrimp aquaculture practices in the north-western province of Sri Lanka. Data and information for profitability analysis of the operation over 10 years were collected from small scale shrimp aquaculture farms in the Puttalam district, Sri Lanka, during April to August, 2014. Economic analysis revealed that the variable cost per unit production and break-even production for the black-tiger shrimp through semi-intensive culture system is 4.4 US$/kg and 2,500 kg respectively. Assuming minimum acceptable rate of return (MARR) of this study is 15%, the NPV value at the end 10 years was found 33,003 US$ for the total capital invested and 34,993 US$ for the equity. Internal Rate of Return (IRR) for the total capital investment is 41% and 74% for the equity. At the end of the ten years, sum of total and net cash flow is 95,176 US$ and 84,093 US$ respectively. Pay-back period for the capital investment is 3 years and it was two years for the equity. Sensitivity analysis indicated that profitability was highly sensitive to changes in sales price. When the value of the sales price falls by 20% or more, the IRR value becomes 13% and is not profitable. The sales price has frequency of 28% of receiving negative NPV, followed by sales quantity (6%) and variable cost (5%). Results of present study indicates that investment is highly profitable although the shrimp farming is most sensitive to changes in sales price.

Key words: Cost-benefit analysis, Economic viability, Profitability, Shrimp farming

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1 INTRODUCTION

Sri Lanka is an island state in the Indian Ocean, south-east of the Indian sub-continent between latitudes 6-10° N longitudes 80-82° E. The island is approximately 65,610 km^2 with a 1,760 km long coastline. The total continental shelf area is around 30,000 km^2 with an average width of approximately 25 km and extending beyond 440 km. Sri Lanka received their sovereign 200 mile Exclusive Economic Zone rights (EEZ) in 1978. The water to land ratio of 3 ha per km^2 of land is considered to be one of the highest such ratio in the world **(**MOFE 2001).

Sri Lanka has a long history of reliance on the sea and coastal areas for nutritional and economic development and well-being of the people. Today the fisheries and aquaculture sector of Sri Lanka is a major source of animal protein providing around 70% to the Sri Lankan population although the current per-capita fish and fishery products consumption level is only at 14.5 kg/year. Sri Lanka's fisheries sector (including aquaculture) has generated 246 million US$ of revenue from the growing export market during the year 2013 and it was 2.5% of total export earnings (MFARD 2014).

The shrimp industry in Sri Lanka has become one of the most important sectors of fisheries and aquaculture. Among many aquaculture initiatives so far; shrimp farming has been the most lucrative commercial aquaculture activity and a good attraction for investment over the past two or three decades. Currently shrimp export is one of major foreign exchange earner in aquaculture exports of the country earning 19.4 million US$ in 2013 (MFARD 2014).

The shrimp aquaculture industry in Sri Lanka started in the early 1980s when few large multinational companies and few medium scale entrepreneurs embarked on shrimp industry (Drengstig, 2013). Although the industry initially emerged in the Batticaloa district on the east coast, the industry was subsequently established in the north-western province during the 1980s. The industry grew slowly towards the beginning of 1990 when there were a total of 60 farms covering an area of 405ha (Siriwardena 1999).

As a result of an attractive package of incentives by the government the shrimp farming grew rapidly. The north-western coastal belt became the hub of the shrimp farming industry of Sri Lanka. By the end of 1999, an estimated 1,300 prawn farms covering an area of 4,500 ha and 80 hatcheries with an annual capacity of 750 million post larvae had developed in the area (FAO 2004).

During this period 30-40 post larvae/m^2 were stocked in earthen ponds and produced 8,000-9,000 kg/ha/year (Drengstig 2013). The industry recorded its peak economic performances in the year 2000 by earning US$ 69.4 million worth of foreign exchange for the total exported volume of 4,855 MT. Export of farmed *P. monodon* accounted for almost 50% of the seafood export sector (UNEP/GPA 2003). Moreover, shrimp farming has contributed towards the development of support industries such as agricultural lime outlets/producers, fiberglass manufacturers, feed outlets, machinery supply and repair facilities, hardware stores and laboratories, cold-storage, shrimp processing, and export industry networks while providing many rural livelihoods.

Shrimp farmers in Sri Lanka typically practice brackish-water monoculture of black tiger prawns (*Penaeus monodon*). At its blooming period, shrimp farms provided approximately 40,000 employment opportunities. However, that number dropped to approximately 8,000 after

disease outbreaks caused a larger number of farmers to abandon their ponds and unemployment among smallholder shrimp farmers became a reality.

In 2010 there were approximately shrimp 603 farms operating along 120 km of coastline in the north-western province, a dramatic decline of farming compared to 1999 (Munasinghe *et al*. 2010). Further, the majority (492) were identified as small scale farms, where the farmer was actively involved in all activities of his fewer shrimp ponds. Compared to 1999, although the farming area of during 2010 was 1,404.6 ha, no considerable difference was noted between the production of 1999 and 2010 (3,820mt and 3,480mt respectively) (MFARD 2014).

However, smallholder farmers face uncertainty and instability, with farmers continuously entering and leaving the industry. This is mainly because of lack of knowledge on profitable operations and lack of understanding of the relevant inputs and of their relationships in the entire production process (Brugère *et al.* 2007). Many of the studies (Philips 1992, Senarath and Visvanathan 2001, Munasinghe *et al.* 2010, Westers 2012, Galappaththi and Berkes 2014) focused more on the environmental, biological and management aspects rather than paying critical attention to the financial aspects of the shrimp production in Sri Lanka.

Efficient financial management of aquaculture can make the difference between profits and losses (Engle and Neira 2005). Therefore, it is essential to know the production costs and its evolution and to determine the factors that affect farm profitability. That will help farmers to manage their farms in a cost-effective way.

Such intervention will help to enhance confidence of small scale farmers to stick to shrimp farming industry. Also careful investigation of the economics of shrimp farming would benefit both producers and policymakers in designing appropriate policy measures enabling increase of profitability in aquaculture (Ahmed *et al*. 2008). For this reason, need to have appropriate information about things such as production by different culture systems, input costs and availability, marketing demand, supply and prices making economic decisions on aquaculture investments.

Though several researchers have looked into the biological and environmental aspects of shrimp farming in Sri Lanka, very limited attention has been paid to the long term economic sustainability. Therefore, the purpose of this study is to fill this gap and evaluate production costs and the profitability (economic viability) of semi intensive small scale shrimp farms. Further evaluating of farm-level profitability is necessary for implementation of sustainable shrimp farming practices to convert of abandoned shrimp farms area in the North-western province, for economic benefits for Sri Lanka.

1.1 Objectives

The purpose of the study was to:

1) Evaluate production costs in order to assess the profitability of semi intensive small scale shrimp farms in North-western province of Sri Lanka.

2) Assess key risk factors that have significant impacts on farm profitability.

3) Provide recommendation with respect to economics to support the development of sustainable shrimp farming practices in Sri Lanka.

2 LITERATURE REVIEW

2.1 Distribution of shrimp (*Penaeus monodon)*

Though there are more than 3,000 shrimp species worldwide, only 40 species are in fact commercially exploited (Whetsone *et al*. 2002). Shrimp farming is based on a few species, mainly selected from penaeidae family for their good reproductive and growth potential.

The black tiger shrimp (*Penaeus monodon*) is the second most cultured shrimp species in the world, after whiteleg shrimp (*Litopenaeus vannamei*) (FAO 2010). The *P. monodon* is naturally distributed in Indo-Pacific, region including eastern coast of Africa and the Arabian peninsula, south-east Asia, sea of Japan and northern Australia (Holthuis 1980).

2.2 Ecology and life history of *P. monodon* shrimp

A marine and lagoon/estuary environment are required to complete the life cycle of black tiger shrimp (Figure 1). The life cycle of penaeid shrimp is divided into 4 stages, larvae, post-larvae, juvenile and adult based on morphological, behavioral, feeding and habitat changes.

The young adult shrimp migrate offshore to the ocean environment where they mature, mate and spawn. Eggs hatch after 12 - 16 hours of fertilization in nauplii larvae. The zoeae larvae, exist as plankton and feeds on microalgae and then metamorphoses in to mysis larvae after six days. The mysis larvae metamorphoses to post larvae within another three days which look like juvenile and adult. They are carried by oceanic currents to estuaries where they obtain protection and nutrition. They remain within the estuaries until they reach late juvenile/early adult stage, which is usually a period of 4-5 months. The shrimp migrate into the open ocean after becoming the early adult stage of development for the remainder of their life.

In aquaculture essential environmental conditions (water salinity, temperature and other water quality parameters) are provided for each stages of shrimp life cycle. Shrimp hatcheries are produced post larvae where they are stocked in grow out facility to grown up to a marketable size.

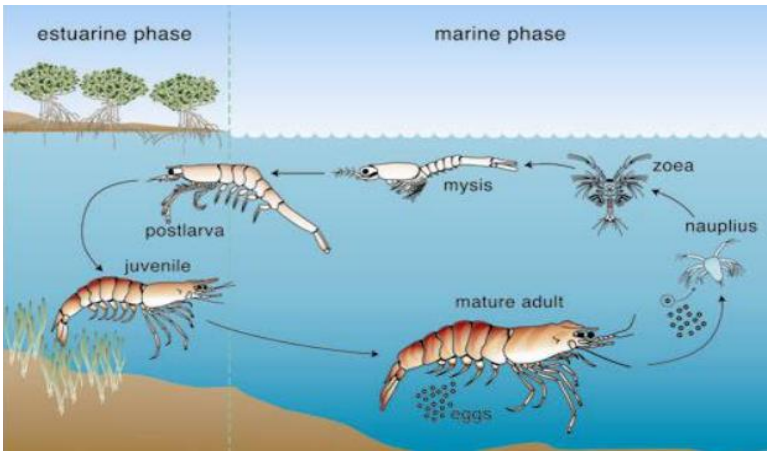

Figure 1: Life cycle of penaeid shrimp (CSIRO 2011).

2.3 Present situation of world shrimp aquaculture

As one of the most important seafood industries, world shrimp farming has undergone an exponential expansion over the last few decades. In 2012, farmed crustaceans accounted for 9.7 percent (6.4 million tonnes) of food fish aquaculture production by volume but 22.4 percent (US$30.9 billion) by value. In 2012 shrimp aquaculture accounted for 15% of the total value of internationally traded fishery products (FAO 2014). During the first half of 2014, the volume traded in the international shrimp market increased by 5-6% compared with the same time period in 2013, mostly as a result of import growth to the US and east Asian markets (Globefish 2014).

High profitability and generation of foreign exchange have been a major reason in the global expansion of shrimp culture, attracting both national and international private companies (Primavera 1998). In the early 1980s, major improvements in hatchery production and feed processing allowed rapid advances in shrimp farming techniques, making it possible to produce dramatically increased yields (Shang *et al.* 1998). However, in 1991 its production had slowed down due to viral disease outbreaks in major production countries.

Among the world leading shrimp producing nations, Thailand, Vietnam and Indonesia, are ranked second, third and fourth respectively after China, the world's largest (FAO 2014). There are some important differences in marketing aspects among these leading shrimp-producing nations. Shrimp production of China is mostly consumed domestically. Most of the shrimp produced in Thailand, Vietnam and Indonesia, in contrast, is exported to major markets in the U.S., Japan and the European Union (EU). Thailand is the world's leading exporter of shrimp.

However, shrimp production practices today are associated with several environmental degradation, disease out-breaks, excessive use of antibiotics and chemicals and volatility in prices and quality (GOAL 2013). Lower production of farm shrimp in Asia and Latin America recorded in 2012-2013 associate with the persistent disease problems, mainly white spot disease and early mortality syndrome (EMS) (Figure 2).

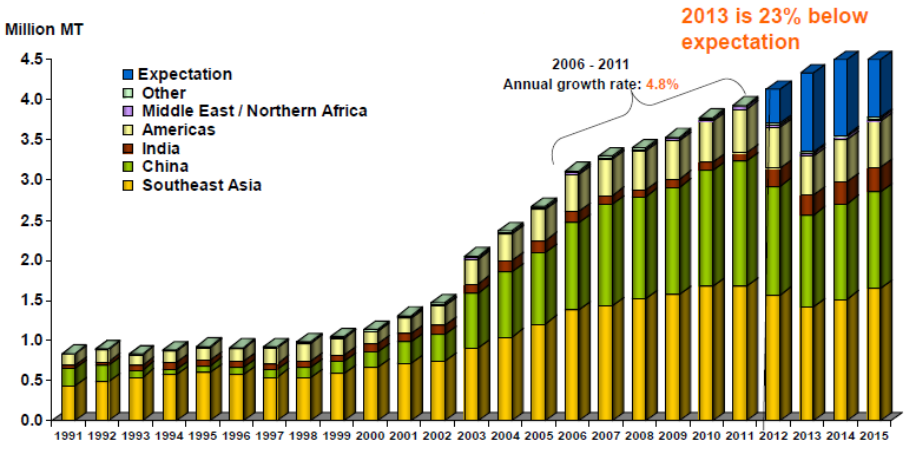

Figure 2: World shrimp aquaculture production by region (1991-2015). FAO (2013) for 1991-2011; GOAL (2013) for 2012-2015. Note: *M. rosenbergii* is not included.

2.4 Overview of the shrimp aquaculture in Sri Lanka

2.4.1 Importance of shrimp aquaculture in Sri Lanka

Shrimp culture is an attractive business in Sri Lanka. It has identified one of the most successful growth areas of aquaculture in Sri Lanka. The shrimp aquaculture is emerging as an important source of foreign exchange in Sri Lanka. In 2013 it produced 4,430 mt and export 1,625 mt of the value of export is 19.4 million US$ (Figures 3 & 4). The vast majority of cultured shrimp production comes from north-western province of the country. However, out-breaks of diseases have caused a major threat to the sustainability of the shrimp industry. The following production figures clearly show the boom and bust nature of the industry.

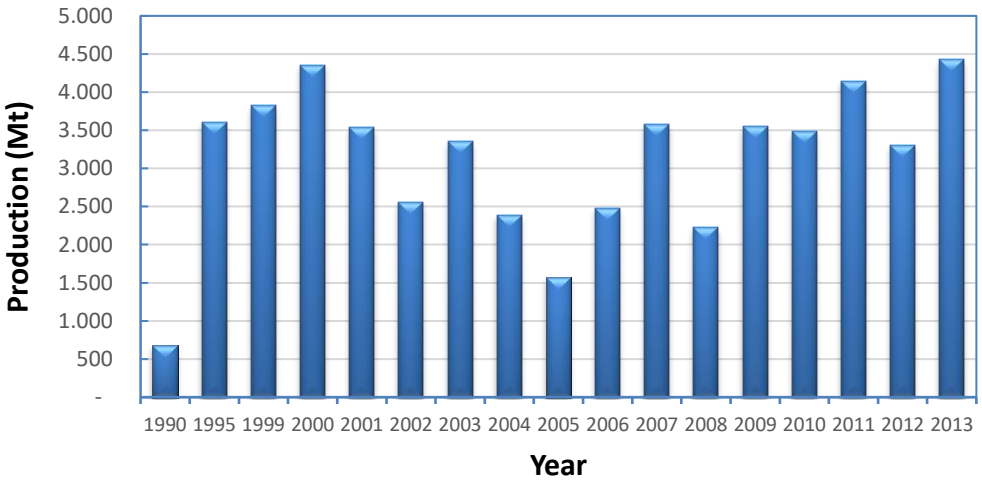

Figure 3: Annual shrimp aquaculture production in Sri Lanka (MFARD 2014).

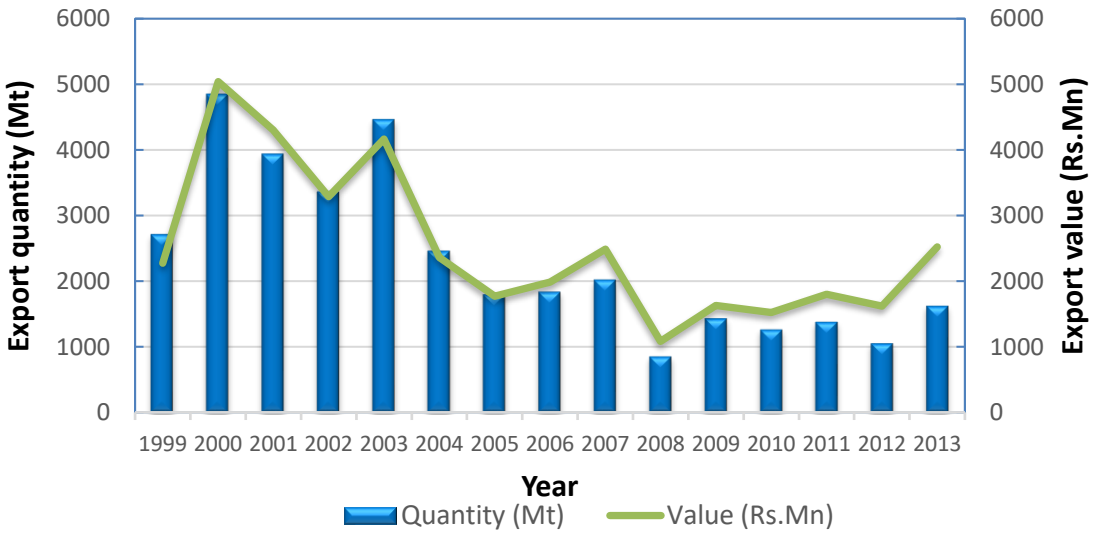

Figure 4: Variation of export quantity and value of shrimp in Sri Lanka. Note: including wild capture shrimp (NAQDA 2014).

2.4.2 Culture facility of shrimp (P. monodon) farming in Sri Lanka

The shrimp industry in Sri Lanka can be divided into following components, post-larva production (hatchery), grow-out (shrimp farming), and shrimp processing. According to Jayasinghe (1995) all shrimp farms in Sri Lanka are operated at semi-intensive and intensive scale, based on major economic and technological differences. Major differences between semi-intensive and intensive levels are in stocking density, aeration systems, farm size, production and investment. Annual shrimp production (kg/ha) from these systems are, 6,663 for semi-intensive and 7,801 for intensive system in 1995.

A study carried out by Dahdouh-Guebas *et al*. (2002) before the year 2000 has categorized three scales of production in Sri Lankan shrimp farming. Based on the classification, the average farm area criterions for large, medium, and small-scale shrimp farms was larger than 15 hectares, between 2 and 15 hectares, and between 0.5 and 0.7 hectares, respectively. Though during late1900s there were relatively large scale commercial operations, currently only small-scale shrimp farms remain in the north western province area (Table 1). There are no constructions of new farms. Munasinghe *et al*. (2010) reported that fifty-four percent of farms of the Puttalam district were less than 1 hectare and 73% of farms were less than 2 ha. Only large scale farms of > 5 ha represented 9% of farms with the remaining 18% being between 2 and 5 ha in 2010.

Table 1: Comparison of past and present impacts (Galappaththi 2013).

Characteristics	Late 90s to early 2000s	Year 2012
Size of the farms	Large (>10ha) /medium (2-10ha) /small scale (<2ha)	Small scale
Number of farms	1,500 - 2,000	About 600
Operating time	Throughout the year	Seasonally (following a crop calendar system)
Proportion of ponds used	All ponds	About one-third of the total number of ponds
Shrimp farm construction	Very common	Not any more (not needed)
Impact to natural resources (water pollution/habitat destruction, etc.)	Relatively high	Relatively low

Semi-intensive operations practice intermediate levels of investment while investors are generally local residents who often play an active management role in production and profit of shrimp production system. Farm labor is recruited from members of the family or from the immediate community nearby.

2.5 The economics of shrimp farming at the farm level

Aquaculture enterprises are usually capital intensive, requiring considerable investment with an extended payback period. Economic considerations in selection of an appropriate aquaculture production system include its potential for economic returns, its economic efficiency and farmer's access to capital (Green *et al.* 1995). For most farming businesses, efficiency is measured in economic terms; that is, the amount of money spent on a farming activity (including costs of inputs, labor, management, cost for land and capital, etc.) is compared to the amount earned through the sale of products (Brummett 2007).

Farm profitability is always dependent on management practices and influenced by fluctuation of market price. Poor management can lead to reduced production and lower profitability even

when prices rise. Instability of market prices and income flows pose major hazards to establishing early profits and ensuring long term viability of the farm. Lack of good assessments of the industry can cause some producers to struggle to survive under fluctuating market conditions (Neiland *et al*. 2001).

Good investment appraisal with sensitivity analysis provides a future values of the most important factors (farm gate price, feed price etc.) would allow a realistic assessment of performance of the investment under fluctuating conditions (Griffin 1995). Thus, successful management of technical and financial measures is a key factor of profitable operations (Nandlal and Pickering 2004). Production costs data help the farmers in decision making and in adjusting to changes and determining the price level under which the product cannot be sold without losses.

Negative net present value (NPV) resulted when a drop in the shrimp price by 15% and the cost of production raises by 15% simultaneously in semi-intensive farming in west Bengal, east coast of India (Bhattacharya 2009). The sensitivity analysis indicates that under the uncertain scenario of international market price traditional shrimp farming system remains more economically viable than semi-intensive farming. In Philippines (Primavera 1991) finds that if the price of shrimp decreases by 20%, intensive farming, extensive farming and traditional farming fail to remain profitable with negative net present value. Only semi-intensive farming was found to be profitable in that case.

Sathiadhas *et al*. (2009) reported the break-even point and profitability of aquaculture farming in India. The results showed that break-even price for black tiger shrimp in semi-intensive and extensive culture is worked out at US$ 3.35/kg and US$ 2.62/kg, while market sales price is US$ 7.29 to US$ 8.33/kg. The break-even price of white shrimp culture worked out to US$ 3.46/kg and US$ 1.8/kg in semi-intensive and improved extensive culture, respectively.

Results of comparison study by Primavera (1993) in three management systems, extensive, semi intensive and intensive shrimp pond culture in Philippines indicates that effect of price changes on the profitability is much higher for intensive farms. Break-even price for extensive (US$ 1.83/kg), semi intensive (US$ 2.72/kg) and intensive (US$ 3.4/kg) in Indonesia suggests that the market risks of intensive farming are considerably higher.

Production costs per kilogram of shrimp were highest in intensive family and commercial farms (US$ 2.7) followed by semi-intensive (US$ 2.1) and poly-culture (US$ 1.05) shrimp farming in China (Cao 2012). Intensive family and commercial farms had similar profits, the highest of all systems (around US$ 9,500 ha^{-1} $crop^{-1}$), while semi-intensive farms obtained about half of that level of profit. This was due to high yields and better market price of intensive farming.

Gonzalez-Romero *et al*. (2014) used a bio-economic model to define optimum pond size for commercial intensive production of the whiteleg shrimp *L. vannamei*. They concluded that ponds covering 2 ha are optimal based on maximum NPV (US$ 63,300), 10% interest rate and IRR (25%).

Though the net present value (NPV) and the internal rate of return (IRR) of ten years farming of *P. vannamei* is US$ 232,000 and 15.1%, and thus very profitable, small changes in stocking density, survival rates and price can result in large losses (Sureshwaran *et al.* 1994).

Valderrama and Engle (2001) was analyzed the profitability of shrimp farming (farm size 10 to over 400 ha) in Honduras under various risk conditions. The effect of risk on profitability was evaluated through Monte Carlo simulation. In this study feed prices and production were correlated with other variables such as total seed costs, feed quantity, total full-time labor, total diesel costs, debt payment, and infrastructure depreciation. Scenario analysis were defined in order to identify possible differences in management strategies to minimize the impact of operation failures. The results indicate that risk is more associated with low yields than high production costs. All farms, regardless of size, need annual shrimp production of more than 450 kg/ha to avoid losses.

3 METHODOLOGY

3.1 Sampling site description

The major source of data for the study was obtained from the three small scale shrimp farms which are located in around latitudes 7° 31' N, longitudes 79° 48' E Ambakandawila, Chilaw within the Puttalam district in North-Western province in Sri Lanka (Figure 5).

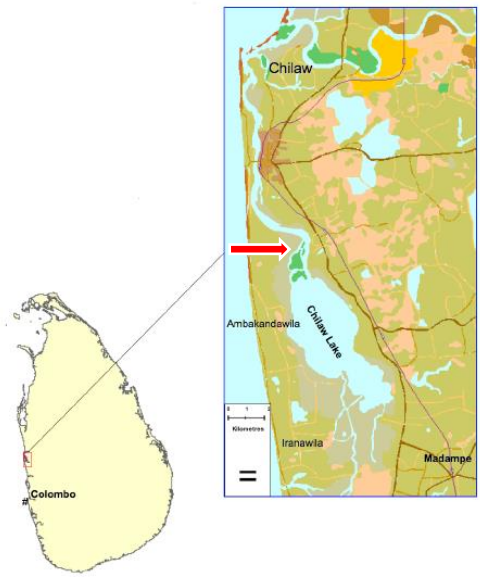

Figure 5: Major shrimp farming areas in Chilaw - North-Western province in Sri Lanka.

3.2 Data collection

Data were collected over 20 week period from month of April to end of August 2014. Data collection methods of the study were, a) participant observations of operating activities in farms b) farmer interview and c) information from farm record keeping books.

For economic analysis, investment cost, production cost and return, data on yield and technical information of farming was used for clarify production cost and assess the profitability and feasibility of a shrimp farm investment.

Total initial investment for the present small scale shrimp farming includes cost for land, building, fencing and equipment. Total production costs are the sum of annual fixed cost and operational/variable cost. Variable costs are directly related to the scale of farm operations at

given time period. Variable costs in production are cost of feed, post larvae, chemicals, electricity, transport and cost for labor, etc. Fixed costs include cost for license/reports, pond renovation, salaries of labors and consultants. Further, total production and sales price were used to calculate gross revenue.

3.3 Analytical technique

In order to assess the profitability of the operation of a shrimp aquaculture farm over 10 years, a model was developed by using Microsoft Excel. Data from a single farm was used as a base case for simulation the model. The model simulates the annual activities of a farm including production, finance, cash flow, capital replacement and depreciation, income taxes, balance sheet and profitability measures. The model also facilitates a risk analysis. The theoretical foundation of the profitability model and the formulas are described in the next section.

3.4 Profitability model of shrimp farming

Economic analysis can provide a systematic evaluation of aquaculture operations, which lead to better management strategies towards economic sustainability. Economic sustainability of any farming system is examined by its profitability based on cost and benefit analysis. Profit is defined as the difference between the total revenue and total cost. While profit is the base for any economic activity, economic analysis provides the basic foundation for decision making.

In aquaculture models different disciplines are used to identify important variables and their relationships by creating formulas (Cloete 2009). A profitability model is defined as a simulation model of an initial investment and subsequent operations. Simulation models have been used to evaluate economic feasibility (Zuniga 2009) and optimize system design and operations in aquaculture (Leung 1986). Profitability models can also be used as a tool for:

- Assessing the cost factors associated with production
- To assess the effects of changes in investment, operational costs in various farming systems and market prices on farming profitability and decision making
- Cost-benefit analysis of research and development options
- Providing an economic decision tools for researchers and stakeholders in farming.

3.5 Measures of profitability

3.5.1 Viability of investments

The profitability of investment of small scale shrimp farming will be estimated by measuring of Net Present Value (NPV), Internal Rate of Return (IRR), Payback period (PBP) and Break-even point (BEP) (Engle 2010; Bhattacharya 2009). The rate used to calculate the present value is known as the discount rate (basically opportunity cost of funds plus a risk addition).

Net Present Value (NPV)

Net Present Value is used on discounted cash flows to evaluate capital investment and to give an indication of the present value of future earnings. Essentially, net present value measures the total amount of gains and losses a project will produce compared to the amount that could be earned simply by saving the money in a bank or investing it in some other opportunity that generates a return equal to the discount rate. Investments with a positive NPV would be

accepted; those with a negative NPV rejected, and a zero value makes the investor indifferent. The NPV value can be calculated by using the formula below (Benninga 2008).

$$NPV = -C_0 + \sum_{i=1}^{T} \frac{C_i}{(1+r)^i}$$

Where, - *C_0 = Initial investment, Ci = Cash flow, r = Discount rate, T= Planning horizon*

Internal Rate of Return (IRR)

The discount rate at which the project has an NPV of zero is called the internal rate of return or IRR (De Ionno 2006; Benninga 2008; Engle 2010). The IRR represents the maximum rate of interest that could be paid on all capital invested or the discount rate at which the annual return becomes zero, or the farm breaks even. In other words, the IRR represents the interest rate at which capital could be borrowed for the farm, or the interest that could be earned on capital (opportunity cost) (Siar *at al*. 2002).

The algorithms available in the Excel software are used for calculating NPV and IRR. These two measures are calculated for the following cash flow series in model:

1. Total capital invested and cash flow after taxes
2. Equity and free (Net) cash flow

Payback period (PBP)

Payback period is the number of years required to recover the amount of the initial investment from the net cash flow, resulting from the investment. In other hand it is the time required for the cumulative NPV to become greater than zero and remain greater than zero over the rest of the life of the project. The payback period is expressed as number of years, not as a cash amount. It can be used to quickly identify investments with the most immediate cash returns. Aquaculture investments are preferred with the shortest payback period (Engle 2010) other factors being equal because of risk considerations.

Break-even point (BEP)

Break-even point is the level of production at which the total cost and total revenue are equal (Curtis and Howard 1993), hence no profit is made and no losses are incurred. It can also be defined as the point where the net profit is zero. The selling price, fixed costs or operating costs will not remain constant resulting in a change in the break-even point. Hence, these should be calculated on a regular basis to reflect changes in costs and prices and in order to maintain profitability.

The break-even price can be compared to the cost of production of a single unit of production. Profit is generated when break-even price is higher than the cost of production. Break-even production and break-even price offer additional insights in to the overall feasibility of the farming (Engle and Neira 2005).

Break-even production and breakeven selling price were calculated as follows:

Break-even production = (Fixed cost + Annuity of investment) / (Farm-gate price per unit –

Variable cost per unit production)

Break even sales price = Fixed cost per unit production + Variable cost per unit production

3.5.2 Financial ratios

Sustainable farming business requires effective planning and financial management. Financial ratios are a useful management tool and key indicators of understanding of farm performance. The most commonly used financial ratios are return on equity, return on investment, net current ratio and debt service coverage ratio.

Net Current Ratio (NCR)

The net current ratio is a liquidity ratio. A higher current ratio indicates the higher capability of a farm to pay back immediately its liabilities. The ratio 1.5 is mostly sufficient. The formula used for calculating current ratio is:

Net Current Ratio: Current assets / Current liabilities

Debt service coverage (DSCR)

Debt service coverage is the ratio of cash available for debt servicing, i.e. to pay annual loan interest and loan repayments (Engle 2010). It can be used as a useful indicator of financial strength of the farm. Usually a debt service coverage ratio of 1.5 to 2.0 is considered as acceptable. If below 1.0 it indicates that there is not enough cash flow to cover loan repayments and loan interest.

Debt service coverage: (Cash flow after tax) / **(**Principal repayment + Interest payments)

3.6 Risk analysis

Risk analysis typically seeks to answer four questions:

- What can go wrong?
- How likely is it to go wrong?
- What would be the consequences of its going wrong?
- What can be done to reduce either the likelihood or the consequences of its going wrong? (Arthur *et al*. 2004).

All businesses operate in environments loaded with risk. These include environmental, biological, operational, financial and social risks. Therefore, it is important to evaluate the risks associated with a business before investing in it (Cloete 2009). In Sri Lanka shrimp aquaculture is considered a high risk business, as it involves relatively high operational cost and uncertainty of shrimp survival during the culture period. Risk is associated with the natural variation in factors affecting profitability over time (Okechi 2004).

Risk analysis provides measures of uncertainty with respect to changes in input variables, such as variable and fixed cost, initial investment cost, production, sales price and interest rates. Therefore, it is significant to identify risk early on in the farming and develop an appropriate risk response plan. There are mainly three techniques used for assessing risks of investments:

Sensitivity Analysis, Scenario Analysis and Monte Carlo Simulations (Brigham and Houston 2004).

3.6.1 Sensitivity analysis

Sensitivity analysis is used to see the effect of changes in one input variable (for example fixed cost, variable cost, equipment cost, production quantity or sales price,) at a time on the profitability of the production. It also identifies the areas where an improvement in performance may have a positive impact on economic performance (Losordo and Westerman 1994).

3.6.2 Scenario analysis

The scenario analysis evaluates the impact of changes in input of more than one variable at the same time looking at for example the optimistic, pessimistic and very pessimistic conditions.

3.6.3 Monte Carlo simulation

Monte Carlo simulation is the most advanced tool for risk assessment. Monte Carlo simulation techniques were used to generate values for individual cost and quantity parameters based on the probability distributions. It is used to specify a probability distribution of the outcome as a function of each of the uncertain input factors. The risk is then the probability of a negative outcome (negative NPV).

3.6.4 Qualitative risk analysis

The qualitative risk analysis was used to assessment of the impact of the identified risk factors. The risk matrix ranks probability of risk depending on the impact they could occur and in case of risk occurring of non-numerical ranges such as low, moderate, high and extreme high. Probability of occurrence and impact level of a risk matrix was developed in order to better understand the risk exposure. These include of environmental risks (e.g. severe weather events, poor water quality), biological risks (disease, lower growth rates, seed quality, predation etc.), operational risks (equipment failure, sharing of equipment, use of chemicals and supplementary feed), financial risks (e.g. sales price changes, currency fluctuations, escalating taxes and interest rates, decreasing market demand, access to credit, increasing production cost) and social risks (lack of skilled manpower, pouching, competition from other sectors). Information for analysis were gathered from reports, case studies, news articles, published research, onsite/field visit and farmers themselves.

3.7 Assumptions

For economic analysis, data on yield, cost and return of farming used for clarify production cost, assess the profitability and feasibility of an investment. Total production costs included the sum of annual fixed cost and operational/variable cost. Variable costs are directly related to the scale of farm operations at given time period. Variable costs in production are cost of feed, post larvae, chemicals, transport and cost for labor, etc.

The costs and benefits were calculated on per farm basis (6,500 m^2) and all the inputs and output related to current study are based on price at the 2014 and US dollars (US$) exchange rate is 130 Rs/US$. The financing of the small scale shrimp farm was assumed to be 40% equity and a loan of 60% of the total investment required, at 11% interest rate, charge and management

fee for loans is set at 2% and loan to be paid back over 10 years. Depreciation was calculated using the straight-line method (equal depreciation costs per annum over the asset's life). Depreciation on buildings was assumed to be 4% each year, equipment by 10% and other investment by 20%. The average accounts receivable from debtors were assumed to be 20% of revenue and accounts payable for creditors were assumed to be 15% of variable costs. Dividends to shareholders are expected to be 10% of profit after income tax which is 8%. We assumed a 15% of discount rate for study (Table 2). Culture period is 4 months and usually two culture cycles were operated during the year.

Table 2: Technical/financial information and assumptions used in one farm model of small scale shrimp farming.

	Value
Technical Information	
Land area (ha)	1.0
Culture pond area (m^2)	6,500
Average pond depth (m)	1.0
FCR	1.3
Stocking Density (PL/m^2)	21
Survival Rate (%)	63
Culture period (months)	4
Culture cycles/year	2
Initial weight of fingerling stocked (g)	0.01
Initial number of fingerling	140,000
Final harvest weight of individual shrimp (g)	27
Financial information	
Loan	60%
Equity	40%
Loan interest	11%
Loan repayments	10 years
Loan Management fees	2%
Assumptions	
Dividend	10%*
Debtors (account received)	20%*
Creditors (Account payable)	15%*
Depreciation of buildings	4%*
Depreciation of equipment	10%*
Depreciation of others	20%*
Discounting rate	15%*
Income tax	8%
Planning horizon (years)	10

*Assumed by author
Exchange rate: 1 US$ = 130 Rs.

3.7.1 Initial investment requirement

Shrimp aquaculture businesses require high levels of capital investment. Total initial investment for the present small scale shrimp farming was 27,000 US$ (farm log book). Of the total, 17,700 US$ was for purchasing land (1 ha), including already constructed earthen ponds, because the entire analysis is based on the utilization of an abandoned shrimp farm. There were three ponds extent in one ha of land area, two ponds were used for farming and other was used as sedimentation/stock pond. Other investments were 1,600 US$ for permanent building, 3,350 US$ for fencing and 4,350 US$ for equipment (Table 3). The total capital requirement for initial operation is somewhat higher than total investment and the difference is called working

capital. It is the amount of money that necessary to operating the farm until the first sales of shrimp. The total working capital value for present study was US$ 1,000 (Appendix 2).

Table 3: Investment cost for small scale shrimp farming.

Investment Cost (US$)	
	Total Cost (US$)
Investment for land + ponds	17,700
Buildings	1,600
Fencing	3,350
Cost of equipment	
Refrigerator	465
Generator	921
Water pump	500
Paddle wheel	2,464
Total	**27,000**

3.7.2 Total cost/Operational cost

Operating costs are the expenses which are related to the operation of a farm, including fixed cost and variable cost (Table 4). The variable cost for the single culture cycle of operation was US$ 10,264 for production of 2,350 kg per culture cycle or US$ 4.37 per/kg of shrimp. There were two culture cycles per year, so variable cost per year is estimated as US$ 20,528 and total production per year was 4,700 kg. Fixed cost is estimated at US$ 2,536 per single culture cycle and US$ 5,012 per year. The total cost of operations for one year period is valued at US$ 25,540.

Table 4: Operational cost (fixed cost and variable cost) for one culture cycle

Total/Operational cost (US$) for one culture cycle			
	Number of units	Unit cost (US$)	Total cost(US$)
Fixed Cost			
License/reports (Year)	3	20	60
Labor charges (2×4 months)	8	155	1,240
Consultant fees (per month)	4	154	616
Pond renovation	2	310	620
		Total Fixed Cost	**2,536**
Variable Cost			
Post Larvae	140,000	0.01	969
Feed:			
Commercial feed	2,850	1.73	4,931
Supplementary feed	480	1.4	672
Electricity	9,150	0.12	1,102
Chemicals			
Lime	4000	0.08	338.46
Dolomite	7000	0.19	1346.15
Other			315.39
Transport cost (fingerlings)			40
Fuel			200
Harvesting charges			300
Other (telephone, etc…)			50
		Total Variable Cost	**10,264**
		TOTAL COST	**12,800**

3.7.3 Production Economics of shrimp aquaculture

Total production for the 6,500 m^2 water area was 2,350 kg of shrimp after one production cycle which is 4 month of culture period (Table 5). There are two production cycles per year, total annual shrimp production at this rate was 4,700 kg or 7,230 kg/ha/year. The stocking density is 21 post-larvae per m^2, average survival rate was 63 percent, while initial average weight of post larvae 0.01 g and end of the culture cycle, average size of the harvested shrimp was around 27.0 g. Feed conversation ratio (FCR) was 1.3.

Table 5: Production economic of small scale shrimp farming.

Month	Average weight (g)	Number of shrimp	Total weight (kg)	Survival rate (%)
0	0.01	140,000	1.4	100
1	4.5	112,000	504	80
2	13.6	98,000	1,333	70
3	19	90,000	1,710	64
4	26.6	88,200	2,350	63

3.7.4 Marketing structure and gross revenue

The range of sales price for the marketing varies with size of shrimps being produced by the farm. There are also differences in the markets supplied, domestic versus export. The gross revenue for one culture cycle was calculated by multiplying the total amount of production (2,350 kg) by its sales price (US$ 8.31) (Table 6). Gross revenue of net profit was calculated as the difference between gross revenue from shrimp sale and total cost of production including fixed cost and variable costs, depreciation, taxes, etc.).

Table 6: Sale price and quantities produced by one culture cycle

	Number of units (kg)	Sales price (US$)	Gross revenue (US$)
Total production	2,350	8.31	19,528

4 RESULTS

4.1 Cash flows analysis

Figure 6 shows the total and net cash flow during ten year period of small scale shrimp farming. Because of the high initial investment cost, both total and net cash flow are negative during the first year of study. Nevertheless, in the remaining years, both total and net cash flow are positive and continues on trend throughout the ten years planning horizon. In 2014, equity value in the cash flow series is US$ 11,200, which is 40% of total financing in shrimp farm operation. At the end of the ten years, the sum over the 10 years of the total and net cash flow is US$ 95,176 and US$ 84,093 respectively (Appendix 8).

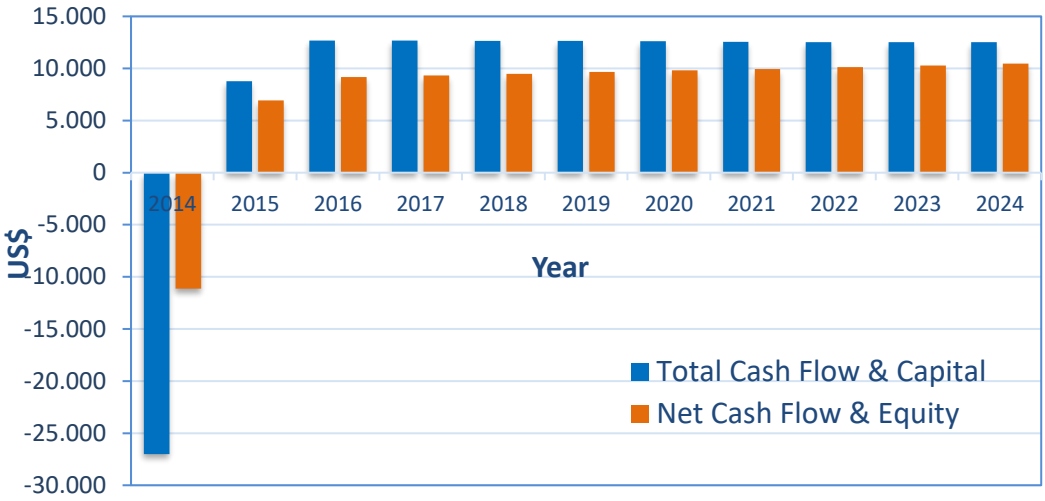

Figure 6: Total and Net cash flow of the during 10 years of operation of small scale shrimp farming.

4.2 Net Present Value (NPV) in cash flow

The assessment of economic viability is done by calculating the viability measures like Net Present Value (NPV) and Internal Rate of Return (IRR). Assuming that the discounting rate (MARR) of this study is 15%, the Net Present Value (NPV) at the end 10 years was found to be US$ 33,003 for the total capital invested and US$ 34,993 for the equity. Based on Figure 7 it was observed that the first three years the accumulated NPV of total cash flow is negative.

4.3 Pay-back period

According to the Figure 7, the pay-back period for total capital investment is 3 years. It means that this venture needs three years to recover the original investment. The higher NPV value and relatively short pay-back period in present study indicates that investment is highly profitable.

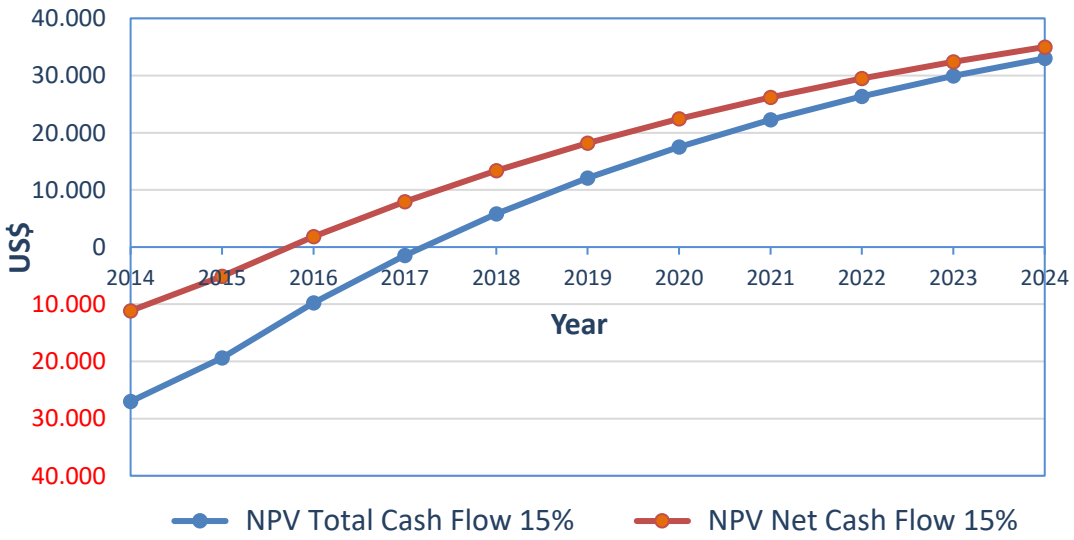

Figure 7: Accumulated Net Present Values and payback period of the during 10 years of operation of shrimp farming.

4.4 Internal Rate of Return (IRR) in cash flow

Internal Rate of Return for the total capital investment is 41% and 74% for the equity in the present study. The IRR is higher than the 15% MARR for present study, indicating that investment is attractive and profitable (Figure 8).

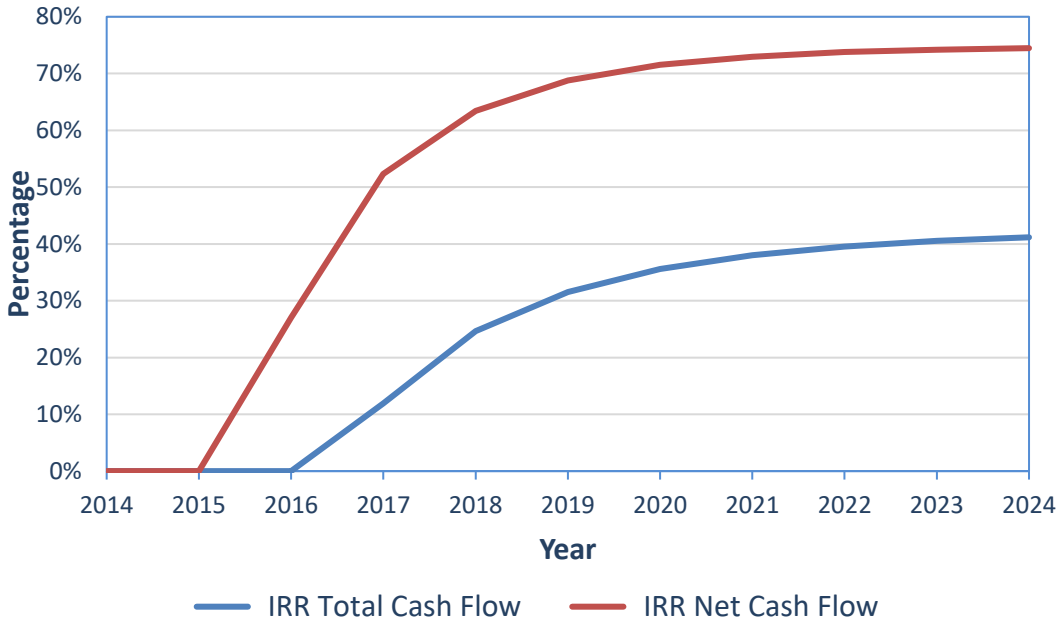

Figure 8: IRR (Internal Rate of Return) in cash flow.

4.5 Break even point and break even price

Variable cost per unit production is US$ 4.37/kg and annuity of the investment is US$ 4,754/year. Based on annual fixed cost (US$ 5,012) the break-even production and breack-even price for the black tiger shrimp in semi intensive system is 2,479 kg per year and US$ 6.45 respectively.

4.6 Financial ratios

In following includes the results of financial rations based on calculation of the initial setup values.

4.6.1 Net current ratio

Net current ratio is above one which indicates that current assets are greater than current liabilities. At the beginning of the farming the assets values are 2.4 times the liabilities values, at the end of the ten year it was 13.6 times the liabilities values. It indicates the higher capability of a farm to pay back immediate its liabilities (Figure 9).

4.6.2 Debt service coverage ratio

A debit service coverage ratio of greater than one indicates that farm has enough cash to pay interest and repayments loans. (Figure 9). In the first year it was 4.7 and end of the ten year 6.1 value indicates that high financial strength of the farm.

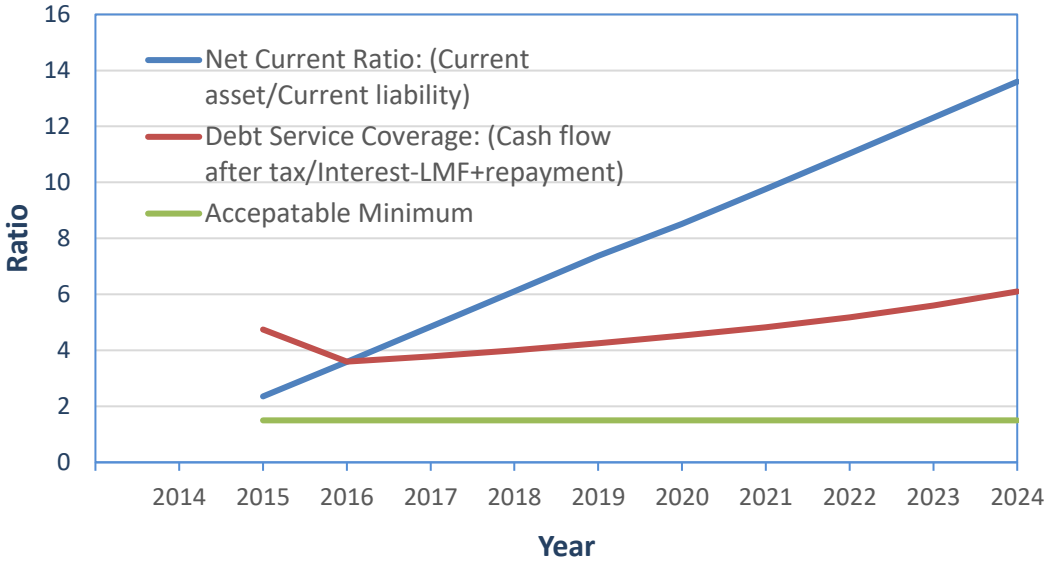

Figure 9: Financial ratios of the small scale shrimp culture in Sri Lanka.

4.7 Breakdown of expenses

Breakdown of expenses show that out of the total operational cost nearly 68% of expenses are variable cost followed by fixed cost which are 17% of total cost (Figure 10). Feed cost represent 55% or more than a half of the variable costs, and it was 44% of total operational cost. Feed cost must be considered as most important items for the variable cost in semi-intensive systems followed by 19% and 11% of chemicals and electricity cost respectively (Figure 11).

Fixed cost for year - round shrimp farming was US$ 5,012 of which management cost including labor salaries constitutes about 49% and 25% of consultant fees. License fees, renovation of pond and canal digging contributed about another 26% of total cost.

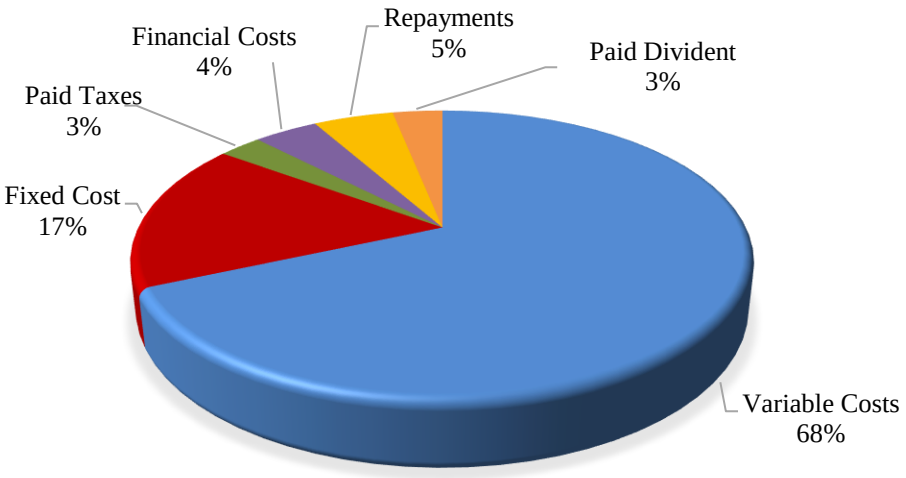

Figure 10: Financial breakdown of small scale shrimp culture in Sri Lanka.

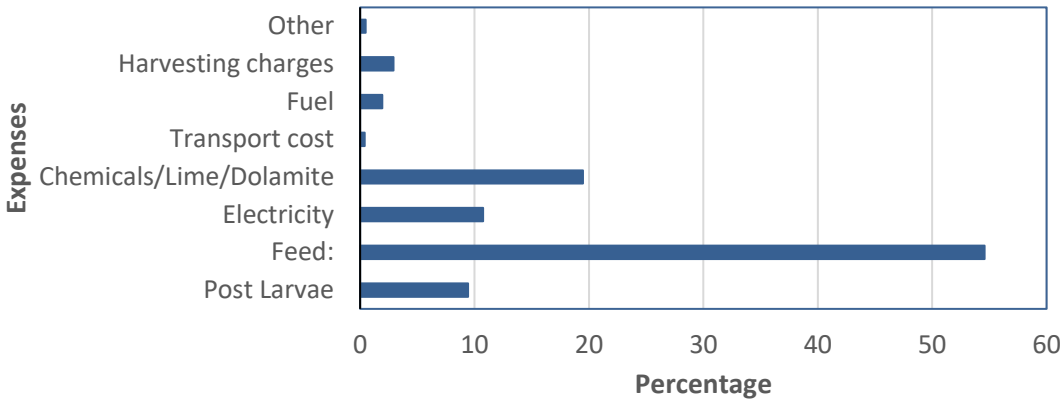

Figure 11: Percentages of major variable cost items in small scale shrimp farming.

4.8 Risk analysis

In shrimp farming, higher intensity is accumulated with the higher financial risk. In more intensive systems, the probability of loss are likely to be higher. World Bank (2000) reported that financial risk in shrimp farming comes from four sources. They are input factors (availability of brood stock, price of post larvae, water quality, credit, etc.); output factors (sales price, production supply to the market, etc.); design factors (site selection, etc.) and natural factors (disease, floods, typhoons, etc.).

4.8.1 Sensitivity analysis

Sensitivity analysis was done for major investment costs including cost of equipment, fixed and variable cost and further sales quantity and sales price. The results of the impact analysis showed that the profitability of the small scale shrimp farm production is most sensitive to variations in the sales price. When the value of the sales price falls by 20% or more, negative NPV in cash flow is no longer profitable and it might destroy the economic viability of the shrimp farm (Figure12). Though variation in the cost of equipment and operational cost (fixed and variable) did not have a significant impact on the farm profitability, variation in variable cost had more impact on the NPV of equity than cost of equipment and fixed costs (Appendix 9).

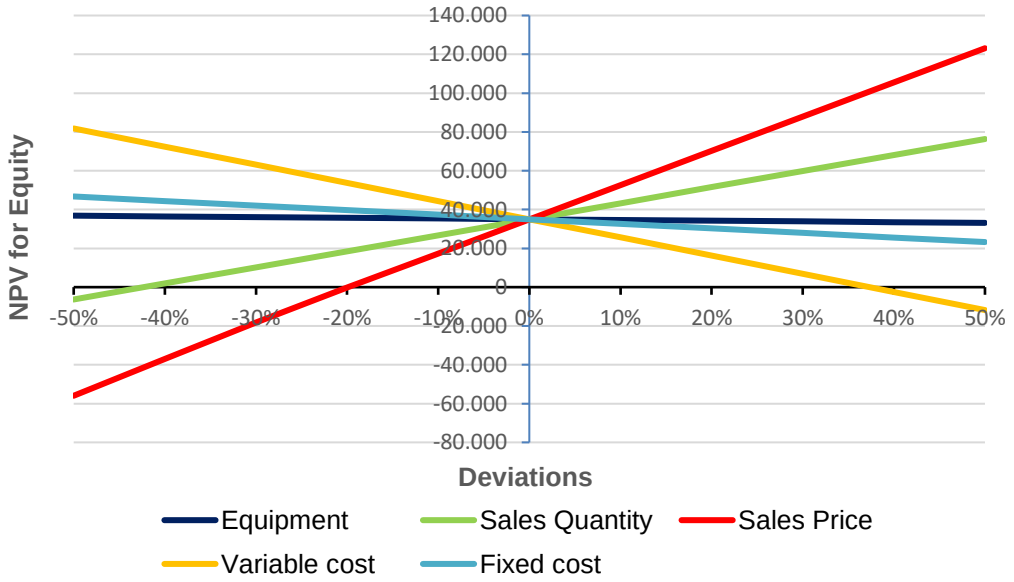

Figure 12: Impact analysis of different variable in small scale shrimp farming.

4.8.2 Scenario summary

Three variable parameters, i.e. cost of equipment, sales quantity and sales price were used for scenario analysis. In pessimistic condition, value of equipment cost increased by 30% and sales quantity decreased by 10%, as well as sales price decreasing by 20% simultaneously, the farming is no longer profitable. Table 7 shows in resulted negative NPV (-592) and IRR (13%) which was less than minimum acceptable rate of return (MARR) of 15%.

Table 7: Different scenarios on equipment cost, quantity and sales price on NPV and IRR in small scale shrimp farming.

Scenario Summary	Base case	Optimistic	Pessimistic	Very Pessimistic
Changing Cells:				
Equipment	100%	80%	130%	150%
Quantity	100%	110%	90%	80%
Sales Price	100%	120%	80%	70%
Result Cells:				
NPV Equity	34,993	76,026	-592	-18,921
IRR Equity	74%	120%	13%	0%

4.8.3 Results of Monte Carlo Simulation

Figure 13 illustrates the risk that resulted from the Monte Carlo simulation analysis. It shows the probability of obtaining negative values of NPV assuming uncertainties in sales price, sales quantity, cost of equipment, variable cost and fixed cost after ten years. In the Monte Carlo method 100 random points of uniform distributions were generated within the define range (0.5-1.5 or from 50% lower up to 50% higher values of input parameters), this was used to represent the five uncertain economic parameters. It should be noted that in the case of say sales price this range is very wide, so the simulation will show very conservative results. Among the risk factors studied, the most critical factor affecting economic performance is the sales price. It has a frequency of 28% of receiving negative NPV, followed by sales quantity (6%) and variable cost (5%).

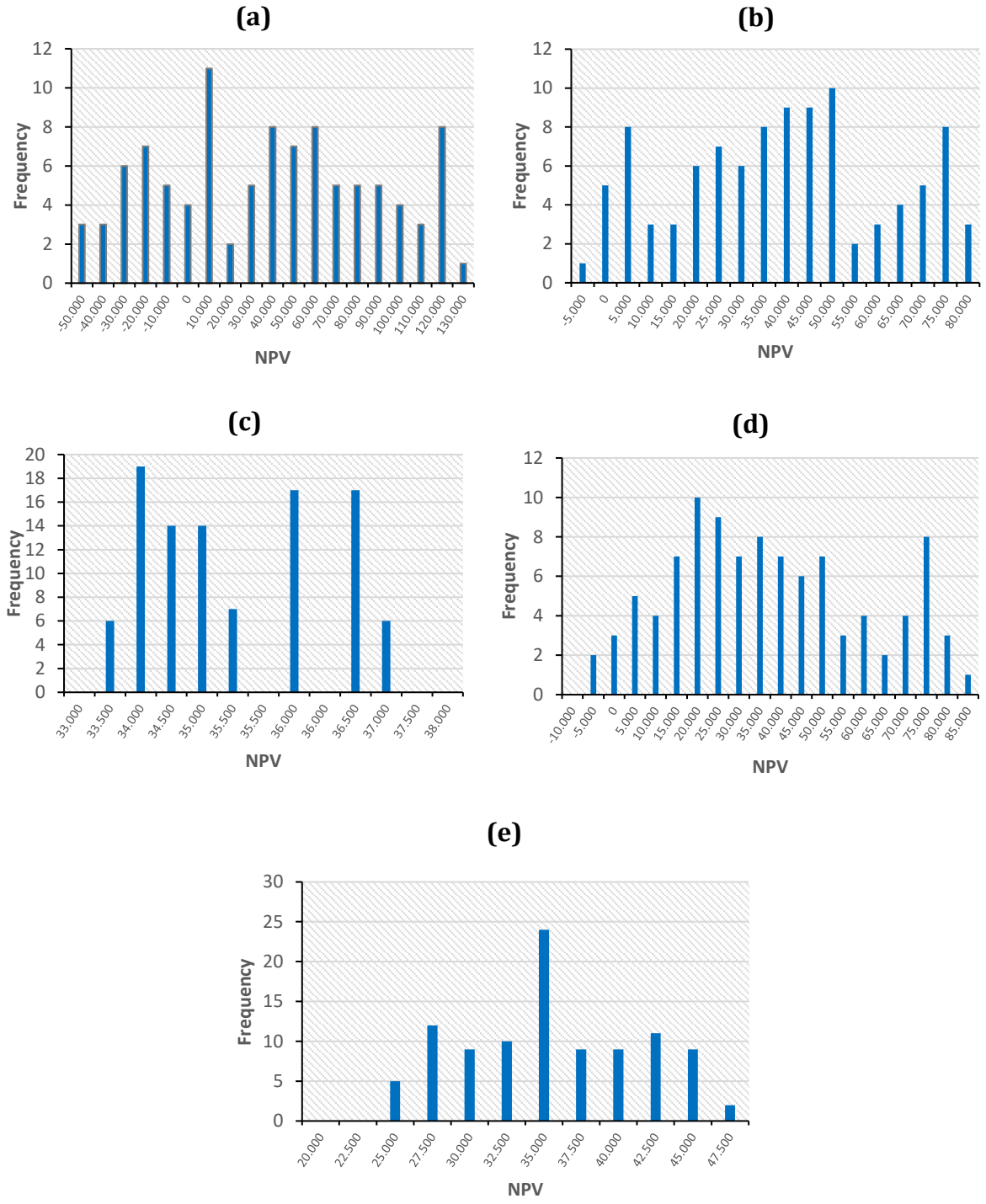

Figure 13: Output probability distributions of Net Present Value of different variables using 15% discount rate. The negative NPV (< 0) are indicate certainty of achieving risk. (a) Sales price (b) Sales quantity (c) Cost of equipment (d) Variable cost and (e) Fixed cost.

4.8.4 Qualitative risk analysis

Qualitative risk assessment of Figure 14 indicates general risk factors for shrimp aquaculture, including financial, biological, environmental, operational and social risks. The risks vary in their spatial extent and in the timing of presence. Some risks factors are always present, whereas others may only occur at specific times.

A greater number of high potential and extreme risks were associated with disease, low production and deterioration of water quality. Shrimp farmers in the North-Western province have dealt with disease problem, which cause lower shrimp yield and result in lower incomes since the 1990s. Thus, many of the farmers who implemented less sustainable practices may have left the industry. The increasing of production cost of different variables had significant financial impact at varying degrees. Government policies including imposing tax incentives, interest rates and environmental policies likely to change and contribute to risk that are moderately effect to the financial status of farming.

There is low probability that flood conditions can be expected to in all the farming areas simultaneously. This situation occurs in general once in 4 to 5 years (UNEP/GPA 2003). Munasinghe *et al*. (2010) reported that during the late dry period from August to September, the salinity levels exceeded 50 ppt which is higher than salinity for optimal shrimp growth in brackish water around the Puttalam district. Although these natural hazards have not occurred frequently. They could have a high impact on profitability.

The little cormorant is a troublesome predator excluding carnivorous fish that can grow in shrimp ponds. Farmers complained that they were robbed of shrimp at night during the later stage of the crop. It was frequently happening and this could lower and moderately threaten the viability of its operations respectively.

Likelihood is described as the probability of an event occurring, ranging from rare events to likely, most likely or frequent events. The qualitative likelihood descriptors used in a risk assessment is presented in Table 8.

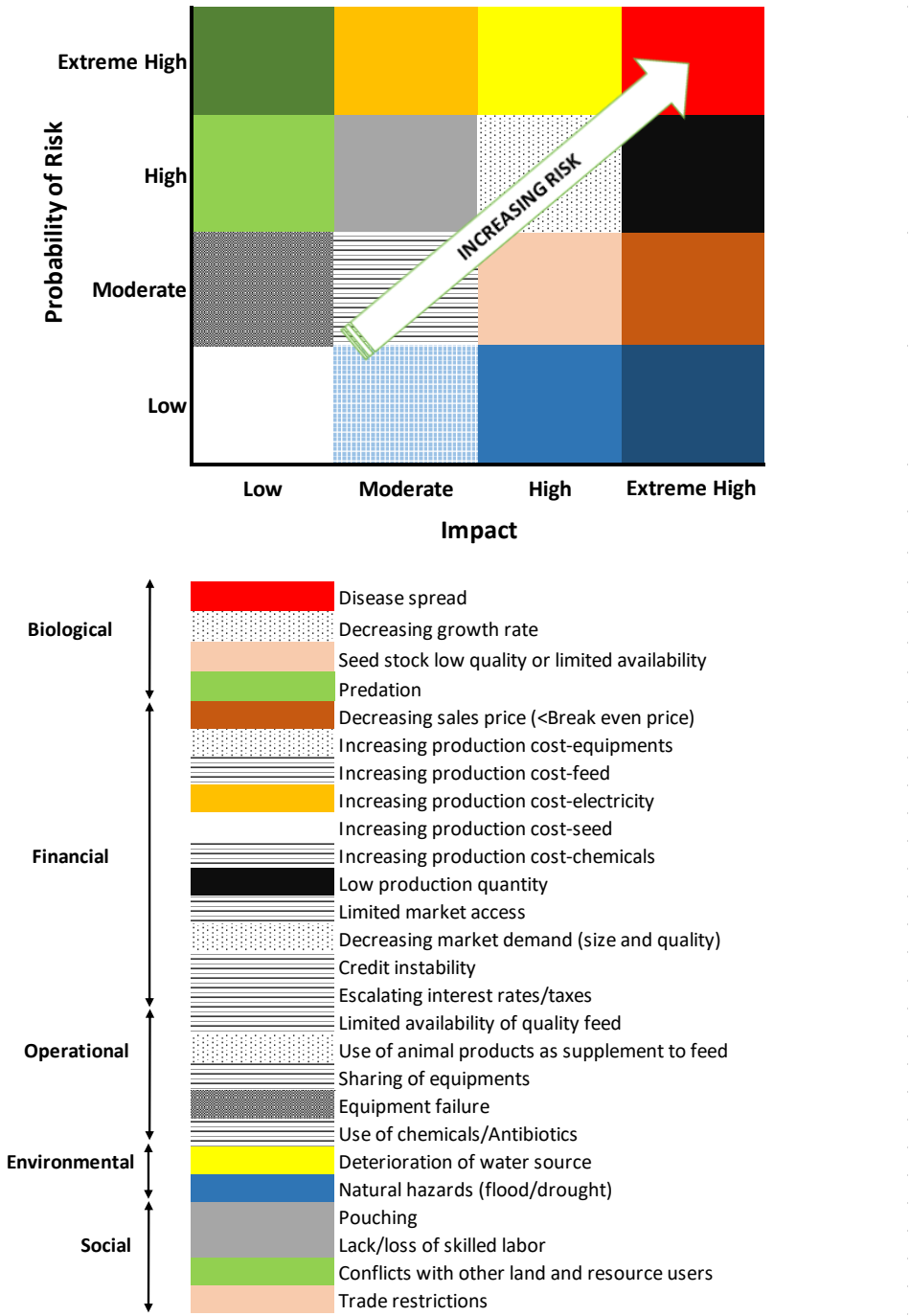

Figure 14: Risk analysis matrix-level of risk in shrimp aquaculture in Sri Lanka.

Table 8: Qualitative measures of likelihood and management options.

Consequence	Probability criteria	Effect	Measures require
Low	Very low, may occur in exceptional circumstances	Low risk	Necessary to maintain assurance level
Moderate	Likely to occur at some time	Moderate financial lost	Tolerate, if cost reduction is acceptable
High	High, probably occur in most circumstances	Significant financial lost	Appropriate additional control measures are needed
Extreme high	Expected to occur in most circumstances	An unacceptable financial loss	Require immediately action

5 DISCUSSION

Aquaculture is a business. The purpose of a business is to generate profit. Profitability is not the same as productivity, as it is also subjected to economic factors such as production costs and market price (Yu *et al.* 2006). The investors will not only need to practice responsible aquaculture but also need to make a profit to maintain sustainable aquaculture (Mwangi 2007). Results of the present study had positive values of NPV, which indicates the economic viability of shrimp farming. It was also shown that IRR was above a minimum attractive rate of return (MARR), and debt service coverage ratio was above 1.5 showing that cash flow of the farm was well above the repayment of loan and its interest. Therefore, the facts above indicate that small scale shrimp farming in Sri Lanka is a profitable activity. Nevertheless, there is no reason to conclude that higher mean value of NPV and IRR are accompanied by lower risk. The long term success of individual farms or industry depends on better management practices. Cao (2012) ranks the major problems that might significantly affect farm profitability in China. The top five problems were: disease outbreak, low farm-gate price, poor seed quality, high feed price and poor water quality.

The ponds size ranging from 0.16-1.0 ha were optimal for efficient management of intensive cultivation of *P. monodon* in Thailand and Taiwan (Kongkeo 1997). Monitoring of water quality and shrimp population and feeding is much easier in small ponds compared to larger ones. Wind action on small ponds is more effective mixing of water (Brune and Drapcho 1991). When shrimp prices are low, or pollution or disease problem occur, small scale farmers can stop their operation for a while, or can reduce stocking density without too much financial effect. 54% of shrimp farms in Puttalam district were less than 1 hectare and 73% of farms were less than two ha (Munasinghe *et al*. 2010). Therefore, small scale farmers get more advantages on management by using small farming area (<1ha).

Decline in world shrimp price is one of the key issues facing shrimp producers. International market demand and prices are clearly factors outside the influence of any shrimp producing country. Funge-Smith and Aeron-Thomas (1995) performed a sensitivity analysis on Thai shrimp farming and found that shrimp price has the most significant effect on overall profitability followed by production and feed price. There are 10% reduction in sales price changing profitability by 73% in his study and it was reduction of NPV by 50% of present study. Shrimp production was the second most important factor and 10% reduction affecting profit by 47% and it was 24% of NPV in present study.

Shrimp prices vary with average size and quality differences, fluctuation of exchange rate, export policies, strength of the economy, consumer preferences (Engle 2010) and supply-demand interactions in the international market at the moment of harvest (Valderrama and Engle 2001). The prices fall when world supply expands faster than world demand, and costs rise as demand for inputs is expanding (Chong 1992). The usual target weight of shrimp is 30g within 4 month of culture period in Sri Lanka. The production of large (>30 g) head-on healthy shrimp that are properly handled and processed after harvest has great demand in the world market. Figure 15 illustrates that variation of farm gate price (Rs) continually increasing last 6 years. It also shows that farm gate price in US$ declined in 2012-2013 due to variation of exchange rate. According to the history of sales prices during the past 6-7 years, shrimp farmers have gradually been receiving more favorable sales prices.

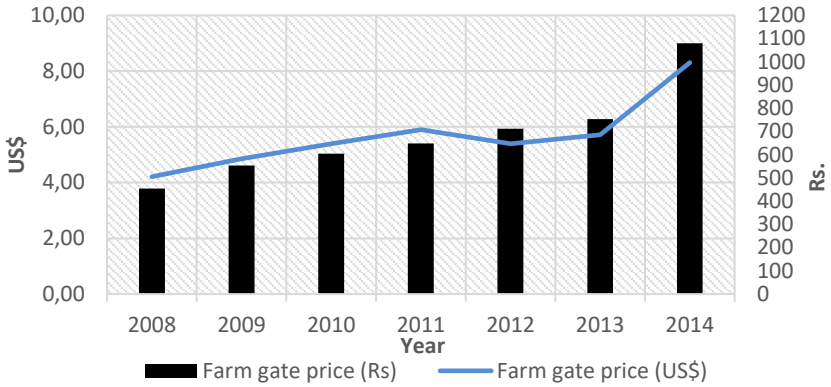

Figure 15: Variations of average farm gate price/kg (>20 g) of shrimp aquaculture in Sri Lanka (King's Aqua services Pvt (Ltd), Sri Lanka).

Shang *et al*. (1998) review the economics of hatchery and grow out of extensive, semi-intensive and intensive phases of shrimp farming in Asia based on the results of a farm survey conducted by the Asian Development Bank (ADB) and Network of Aquaculture Centers in Asia-Pacific (NACA) in 1994-1995. The results can be seen in Figure 16 and Appendix 10. The survey indicated that production cost per kg was US$ 4.56 in Sri Lanka which is less than the present value (US$ 6.45) in 2014. It was higher than other Asian countries from China (US$ 2.27), Vietnam (US$ 3.3), Indonesia (US$ 3.78) and Philippines (US$ 4.0), but lower than Malaysia (US$ 5.5) and India (US$ 5.96) in 1994. For semi intensive grow out systems Indonesia had the highest profit (US$ 3.05/kg), followed by Sri Lanka (US$ 3.00/kg), the Philippines (US$ 2.54) and Vietnam (US$ 2.29). The relatively high food conversion ratio (1.9) compared to Indonesia (1.4) is the major factor responsible for higher production cost in Sri Lanka. Nevertheless Sri Lanka has decreased profit (US$/kg) from US$ 3.0 in 1994 to US$ 1.86 in 2014, while sales price has increased from 7.56 to 8.3 US$/kg (ADB/NACA 1996). Seed is the second most significant variable cost (19%) in 1994, however it was 9% in the present study. However cost of chemicals has significantly been increased when compared with in 1994. Fallowing (Shang *et al*. 1998) the ponds after each harvest usually reduces the cost of chemicals.

In 1994 stocking of 29 PL/m^2 resulted in a total production of 5,040 kg/ha/year. It was 7,230 kg/ha/year in the present study indicating that small scale farmers are more efficient in the utilization of inputs. Sri Lanka exhibited a lower profit of US$ 1.14 per kg, due to increases of production cost during the period of 1994 to 2014. In 1994, Sri Lanka farmers enjoyed relatively high farm gate prices compared with other Asian countries. While production costs have continually risen in recent years, the lower export price and reasonable local market price caused many farmers to sell their harvest to the local market, where they can received an equivalent price for smaller shrimps (Munasinghe *et al.* 2010). Applying the resource cost ratio (RCR) approach to the Asian shrimp farming industry, Shang *et al*. (1998) indicated that Thailand, Indonesia and Sri Lanka had a comparative advantage in producing and exporting shrimp to markets like Japan and/or US countries.

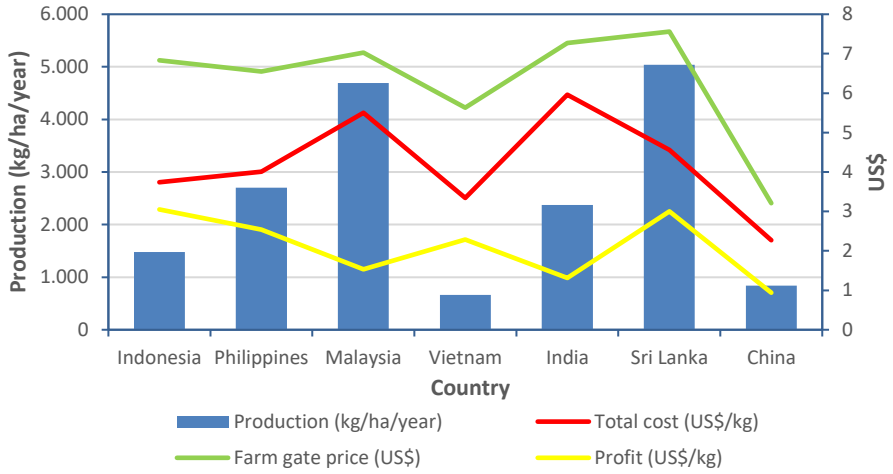

Figure 16: Production, cost and revenue of semi-intensive shrimp farming systems in Asian countries, 1994 (ADB/NACA 1996).

The resent survey by Son et al. (2010) examined the production and economic efficiencies of eighty black tiger prawn farms in the Mekong delta, Vietnam. He revealed that stocking of 17 PL m^2 with a survival rate of 55% resulted in an average yield of 2,470 kg/ha/crop, final weight of shrimp was 25g, farm gate price 5.7 US$/kg and the net income received was 6,768 US$ ha/crop (US$ 2.3/kg) after 150 culture days. Average production cost amounted to 3.4 US$/kg, and feed, the largest operating cost item accounted for 58% of the production cost. The total production cost of 3.4 US$/kg is lower than those reported (US$ 6.45/kg) in present study of Sri Lanka. This lower production cost was resulted due to low labor costs and land rentals as well as low capital investment in the family-operated prawn farms in Vietnam. Nevertheless total production (3,615 kg/ha/crop) is higher than compared with relatively short culture period (120 days) of the present study. The poor weight gains resulted in lengthening the crop period, increasing costs and further lowering the production and profit margin in Vietnam. Relatively higher survival rate and growth rate of a short period of time resulted in higher production and average individual weight (27 g) of harvested shrimp in Sri Lanka. However, initial investment costs and depreciation values were not evaluated in the study of Vietnam.

Shrimp farming has created various socio-economic and environmental problems in many countries and sustainability is a major concern and remains a challenge of the industry. Therefore sustainable farming practices should be in harmony with other economic activities in natural resources, thus balanced with production, marketing and other supporting services while producing a reasonable and relatively stable income and benefits to the farmers. Moreover farming system having bio-technically, environmentally sound and socio-economical viability is important.

Following measures are important while improving economic viability and long term farm level sustainability of small scale shrimp farmers in Sri Lanka:

- increase in production quantity
- reduction in production costs
- diversify market and products
- improve quality of products
- minimizing negative environmental impacts

The present study only evaluated the effect of varying economic variables on the profitability of shrimp farming. However, other biological, external or technical aspects which are of great importance to the economic viability of such investments were not evaluated in this analysis (Zuniga 2009). Therefore, investors need to look at bio-economic modeling, effects of growth, mortality of shrimp, diseases, predation, environmental conditions, climate, market demand and other issues before making a decision. Cao (2012) indicated that disease outbreak could cause only 12% to 36% crop reduction at the best or most probable cases, and as much as 78% crop reduction at the worst case in shrimp farming in China. However, under the worst case scenario in his model, massive crop failure would produce zero to negative returns for intensive farming. The probability of yield lost was 15.6 times higher in the wet season than dry season while survival rate of the dry season crop (59%) was significantly higher ($p<0.05$) when compared with wet season crop (49%) in Vietnam (Son *et al*. 2010). The reason might be more difficulties of pond drying, lower salinity and more risky of disease spreading due to pond water overflow during wet season. Further social costs and taxes on discharging effluents are important cost items, which need to be considered in a conventional financial analysis.

The required information was collected from a limited area which may not present the actual situation all over the country. Land value in initial investments cost and interest rates on loans can be highly variable with place and year. Therefore, constant input and output expenses used in present analysis may not be true indicators for future economic analysis. There are two production cycles operated during dry and wet seasons of year. There are differences of productivity between these two cycles. Such differences were not accounted for in this study.

6 CONCLUSION AND RECOMMENDATIONS

The goal of this study is to do an assessment of the financial viability of small scale shrimp farming in the North-Western province of Sri Lanka by addressing the economical sustainability of the shrimp farming systems in the long run. The profitability model as a decision support tool was developed to assess the profitability of shrimp farming enterprises. The analysis explains the systems across different economic viability measures like net present value, internal rate of return, pay- back period and break-even point. Furthermore, risk analysis measures of uncertainty are calculated with respect to changes in input variables, such as operational cost, investment cost, production and sales price. The development of a risk assessment will help the actors at the different levels to make informed decisions regarding economic sustainability of shrimp farming.

Operating a 1-ha shrimp farm (6.5 ha of pond area) give a total and net cash flow of US$ 8,775 and US$ 6,927 after one year operation and it was US$ 95,176 and US$ 84,093 in sum of cash flow at the end of a ten years operation. The high NPV and IRR values and a relatively short pay-back period in the present study indicate that the investment is highly profitable. The net current ratio and debt service coverage ratio was continually above 1.5 showing that higher capability of a farm to pay back immediately its liabilities and cash flow from the operations is well above the repayment and interest of loans, which have to be paid. A positive cash flow after first year of operation means that the net income is higher than the amount needed to cover expenses. Risk analysis showed that farming is most sensitive to sales price, while other factors had less effects. Significant decrease (20%) in sales price results in an IRR under 13% which is not profitable and might destroy the economic viability of the shrimp farm. Though the operation is profitable, it has a 28% of frequency of considerable risk receiving negative NPV. Thus, in order to avoid huge losses following uncertainties in the international market price in

the shrimp industry, care and attention must be paid to achieving reasonable farm gate price. The results of economic indicators of this evaluation help to assist potential investors in making their decisions.

The cost of initial investment vary depending on value of farm site, pond preparation and production strategy. Land is often the major initial investment. However, due to the availability of already constructed ponds in the north-western area, farmers do not need to construct any new ponds. Infrastructure facilities, equipment, feed, post larvae, electricity, labor and chemicals are major inputs for producing shrimp. Though stocking density was positively correlated to profitability, it should not exceed a pond's carrying capacity. Electricity use was identified as a hotspot of shrimp production. Operating of re-circulating water systems, water exchanged only when necessary, rather than on a routine schedule were activities which help further reduce additional use of electricity or fuel for pumping water.

Though various policies exist for development of shrimp aquaculture, so far no policy exists in relation to the marketing of shrimp products. One of the threats to the Sri Lankan shrimp industry is price fluctuations of European, Japan and United States markets because of environmental and health concerns of consumers. Dependence on EU for market share has increased risk of market failure.

The following are important for marketing of shrimp farming in Sri Lanka:

- Marketing campaigns to raise awareness on environmentally and socially sustainable farming practices
- product differentiation and coordinate its market promotion
- international trade agreements
- product quality control
- privilege to new production strategies
- genetically modified products
- eco-labeled or organic certified shrimp products

Organic aquaculture is a market-driven initiative and organic products receive 10-40% higher price than conventional products (INFOFISH 2011). The European Union (EU), United States of America and Japan are the major markets for organic/eco-labeled or certified food and beverage. Certification programs have not been widely established in Sri Lanka since the majority of shrimp farms are small-scale, family operated. Further prohibited chemicals in any of the countries where the shrimp will be sold should never be used. In order to take right actions and avoid financial losses due to reduction of sales price, it is necessary to closely monitor fluctuations of demand and sales prices in local/international markets.

Reducing surcharge for export processed shrimp products to be vary (fresh - frozen/chilled, dried and canned) according to the variation of world price of frozen shrimp. It is advisable for farmers/exporters to increase value addition in processing to their shrimp and thus increase their market opportunities.

The feed conversion ratio (FCR) is around 1.3 in present study indicates that relatively higher feeding efficiencies, compared with 1.9 reported in Sri Lanka by Shang *et al*. (1998), recommended value of 1.6-1.9 by UNEP/GPA (2003) and 1.6 in Vietnam (Son *et al*. 2011). The feed cost accounts for 55% of the variable cost, since the feed is mainly imported from south-east Asian countries like Thailand. A majority of farmers used wild captured shellfish and fish as a high protein supplement to increase growth rate and reduce feed cost. The clams

and fish were not always cooked or commercial feed was not screened for pathogens. Therefore, it is suggested that further research would support the development of own local feed with less cost, high nutritional and pathogen free feed by utilizing locally available materials for feed instead of imported ones.

According to Munasinghe *et al*. (2010), 80% of farmers used lime and/or dolomite to adjust the pond bottom pH. Nevertheless, amount applied depends on the farmers' experience and economic situation. The chemical is the second most variable cost (US$ 2000) and it was 19% of variable cost in the present study. To avoid an irregular basic application, farmers need to check the soil pH and calculate the amount of lime and dolomite to be applied. Recommended lime application during pond preparation was <1,000 kg/ha of $CaCO_3$ lime or <500 kg/ha of $Ca(OH)_2$ lime when soil pH is higher than 6 and it was <3,000 kg/ha of $CaCO_3$ lime or <1,500 kg/ha of $Ca(OH)_2$ lime when soil pH is less than 5 (MPEDA/NACA 2003).

Shrimp farming in Sri Lanka is facing many challenges such as disease outbreaks, limitation of resources and increasing production costs. High quality of pond management and maintaining ambient environment for acceptable ranges through adopting the best management practices (BMP) for shrimps are major factors for ensuring economic sustainability of farming systems. It reduces outbreaks of disease which is a most critical factor determining farm profit. Introducing of specific pathogen free (SPF) strains of white shrimp (*Litopenaeus vannamei),* which were more disease resistant and grew faster than local strains (Lightner 2005) will help to solve the issue of poor seed quality and reduce the risk of disease outbreak. The majority of small scale farmers have little knowledge about operational and management decisions for sustainable farming. As a result, rising production cost became a critical factor determining farms profits.

Therefore, assessment of long term production trends,

- understanding, upgrade the knowledge
- management need awareness and enhance extension training services
- encourage of better record keeping are important for learning their mistakes.

Many small-scale shrimp producers have had to produce and market their products without access to reliable or affordable input suppliers, integrated production-distribution chains with buyers, retailers and processors, financial, technical or transport services and particularly towards improving biosecurity. Therefore, it is necessary to establish strong clusters in order to provide opportunity to increase competitiveness of the industry by strengthening network among the stakeholders including, hatcheries, producers, collection points and markets, traders, processing, exporters and all other associated services like feed and chemical suppliers, consultant services, transportation, labor contractors etc.

Shrimp farmers are reporting that lack of financial resources was a major problem for running the business of shrimp farming (Munasinghe *et al*. 2010). The household economy of small scale farmers, who generally have few assets or savings, are not enough for initial implementation of shrimp farming. Farmers are reluctant to take bank loans because of high interest rates. Because of high risks and production failures, banks are also reluctant to provide loans for shrimp farming. As high level of initial cash required for investment, it is recommended to provide loan/financial support by the government at the micro-level with reasonable interest rates.

Strengthening the present community based shrimp farmers associations to manage and operate financial support schemes to provide credit and capital resources to members in crisis situations is necessary. Farms are partially insured against natural disasters, such as flooding, drought, disease or uncertain financial losses and they themselves have also contributed to a common fund by contributing some proportion of profits for many years. The government authorities have also required to add to the fund in order to help cover potential losses. Further the government of Sri Lanka needs strongly taken steps to impose a tax of shrimps exported in order to subsidy for environmental management, research and development to ensure that sustainability and long run of shrimp farming in Sri Lanka.

A useful benefit of retained earnings is to reinvest. Farmers may have plans to expand their farms so that profit can be turned back into through infrastructure and products development, services or to invest in more marketing and promotion that will be more sustainable.

Despite the fact that present study evaluates only small scale to assess the profitability of shrimp farming, it is worthwhile to look at large or intensive commercial scale in the future studies.

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APPENDIX

Appendix 1: Cost and expenses of three small scale farms in north-western province of Sri Lanka.

	Farm 1	Farm 2	Farm 3
Investment Cost (US$)			
Investment for land+ponds	17,700	34,615	**
Buildings	1,600	*	3,270
Fencing	3,350	8,077	3,100
Cost of equipment	4,350	692	580
Total Investment Cost	**27,000**	**43,384**	**6,950**
Fixed Cost			
License/reports(year)	60	60	60
Labor charges (2× 4 month)	1,240	1,850	1,230
Consultant fees (per month)	616	615	615
Pond renovation	620	970	925
Total Fixed Cost	**2,536**	**3,495**	**2,830**
Variable Cost			
Post Larvae	969	981	948
Feed:			
Commercial feed	4,931	5,162	4,910
Supplementary feed	672	462	580
Electricity	1,102	1,154	1,080
Chemicals/Lime/Dolomite	2,000	1,769	1,923
Transport cost (fingerlings)	40	8	12
Fuel	200		
Harvesting charges	300	308	308
Other (telephone, etc…)	50	100	75
Total Variable Cost	**10,264**	**9,944**	**9,836**
TOTAL COST	**12,800**	**13,439**	**12,666**
Production	2350	2420	2400
Gross Revenue	19,523	20,060	19,392

Note: * Farm 2 (cost of buildings and several equipment were included in land value)
** Farm 3 (land value is not included as farmer owned land)

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Appendix 2: Profitability model - Summary, Assumptions and Results

Assumptions and Results

		2014					
				Discounting Rate	15%	MARR	
Investment:		US$		Planning Horizon	10	years	
Land		17,700					
Buildings		1,600					
Equipment	100%	4,350			**Total Cap.**	**Equity**	
Other		3,350		**NPV of Cash Flow**	**33,003**	**34,993**	
Total		**27,000**		**Internal Rate**	**41%**	**74%**	
Financing:							
Working Capital		1,000		**Capital/Equity**	**9.5**		
Total Financing		28,000		**after 10 years**			
Equity	100%	40%					
Loan Repayments	100%	10	years	Minimum Cash Account	664		
Loan Interest	100%	11%					

Operations:			**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	
Sales Quantity	100%		4,700	4,700	4,700	4,700	4,700	4,700	4,700	4,700	4,700	4,700	kg/year
Sales Price	100%		8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	US$/kg
Variable Cost	100%	4.37	US$/kg										
Fixed Cost	100%	5,012	US$/year										
Inventory Build-up													
Debtors (Acc received)	20%	of turnover											
Creditors(Acc payable)	15%	of variable cost											
Dividend	10%	of profit											
Depreciation Buildings	4%												
Depreciation Equipment	10%												
Depreciation Other	20%												
Loan Management Fees	2%												
Income Tax	8%												

Breakdown Costs		
Variable Costs	205,390.00	68%
Fixed Cost	50,120.00	17%
Paid Taxes	8,153.55	3%
Financial Costs	12,163.20	4%
Repayments	15,120.00	5%
Paid Divident	9,410.18	3%
Total	300,356.94	

Colour code
Assumptions
Results

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Appendix 3: Profitability model - Investment and Finance

Investment and Financing													
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
			1	2	3	4	5	6	7	8	9	10	
Investment:													
Land		17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	
Buildings		1,600	1,536	1,472	1,408	1,344	1,280	1,216	1,152	1,088	1,024	960	
Equipment		4,350	3,915	3,480	3,045	2,610	2,175	1,740	1,305	870	435	0	
Other		3,350	2,680	2,010	1,340	670							
Booked Value		**27,000**	**25,831**	**24,662**	**23,493**	**22,324**	**21,155**	**20,656**	**20,157**	**19,658**	**19,159**	**18,660**	
Depreciation:													
Depreciation Buildings	4%		64	64	64	64	64	64	64	64	64	64	640
Depreciation Equipm.	10%		435	435	435	435	435	435	435	435	435	435	4,350
Depreciation Other	20%		670	670	670	670	670						3,350
Total Depreciation			1,169	1,169	1,169	1,169	1,169	499	499	499	499	499	8,340
Financing:		28,000											
Equity	40%	11,200											
Loans	60%	16,800											
Repayment	10			1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	15,120
Principal		16,800	16,800	15,120	13,440	11,760	10,080	8,400	6,720	5,040	3,360	1,680	
Interest	11%		1,848	1,848	1,663	1,478	1,294	1,109	924	739	554	370	11,827
Loan Managem. Fees	2%	336											

Appendix 4: Profitability model - Operations statement

Operations													
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
Operations Statement													
Sales kg/year			4,700	4,700	4,700	4,700	4,700	4,700	4,700	4,700	4,700	4,700	47,000
Price USD/kg			8	8	8	8	8	8	8	8	8	8	
Revenue (US$/year)			39,057	39,057	39,057	39,057	39,057	39,057	39,057	39,057	39,057	39,057	390,570
Variable Cost	4		20,539	20,539	20,539	20,539	20,539	20,539	20,539	20,539	20,539	20,539	205,390
Fixed Cost	5012		5,012	5,012	5,012	5,012	5,012	5,012	5,012	5,012	5,012	5,012	50,120
Diverse Taxes													
Operating Surplus (EBITDA)			13,506	13,506	13,506	13,506	13,506	13,506	13,506	13,506	13,506	13,506	135,060
Inventory Movement													
Depreciation			1,169	1,169	1,169	1,169	1,169	499	499	499	499	499	8,340
EBIT (Operating Gain/Loss)			12,337	12,337	12,337	12,337	12,337	13,007	13,007	13,007	13,007	13,007	126,720
Financial cost (Interest+LMF)		336	1,848	1,848	1,663	1,478	1,294	1,109	924	739	554	370	12,163
EBT (Profit Before Tax)		-336	10,489	10,489	10,674	10,859	11,043	11,898	12,083	12,268	12,453	12,637	114,557
Loss Transfer	0	-336	0	0	0	0	0	0	0	0	0	0	
Taxable Profit		0	10,153	10,489	10,674	10,859	11,043	11,898	12,083	12,268	12,453	12,637	
Income Tax	8%	0	812	839	854	869	883	952	967	981	996	1,011	9,165
Profit After Tax		-336	9,677	9,650	9,820	9,990	10,160	10,946	11,116	11,286	11,456	11,626	105,392
Dividend	10%	0	968	965	982	999	1,016	1,095	1,112	1,129	1,146	1,163	10,573
Net Profit/Loss		-336	8,709	8,685	8,838	8,991	9,144	9,852	10,005	10,158	10,311	10,464	94,819

Appendix 5: Profitability model - Cash flow

Cash Flow													
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Cash Flow													
EBITDA Operating Surplus		0	13,506	13,506	13,506	13,506	13,506	13,506	13,506	13,506	13,506	13,506	135,060
Debtor Changes			7,811	0	0	0	0	0	0	0	0	0	7,811
Creditor Changes			3,081	0	0	0	0	0	0	0	0	0	3,081
Inventory Changes			0	0	0	0	0	0	0	0	0	0	0
Cash Flow before Tax		0	8,775	13,506	13,506	13,506	13,506	13,506	13,506	13,506	13,506	13,506	130,329
Paid Taxes			0	812	839	854	869	883	952	967	981	996	8,154
Cash Flow after Tax		0	8,775	12,694	12,667	12,652	12,637	12,623	12,554	12,539	12,525	12,510	122,176
Financial Costs (Interest-LMF)		336	1,848	1,848	1,663	1,478	1,294	1,109	924	739	554	370	12,163
Repayment		0	0	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	15,120
Free Net Cash Flow		-336	6,927	9,166	9,324	9,494	9,664	9,834	9,950	10,120	10,290	10,460	94,893
Paid Dividend			0	968	965	982	999	1,016	1,095	1,112	1,129	1,146	9,410
Financing - (Working capital)		1,000											
Cash Movement		664	6,927	8,198	8,359	8,512	8,665	8,818	8,856	9,009	9,162	9,315	86,483

Appendix 6: Profitability model - Source and allocation of funds

Source and Allocation of Funds													
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Source of Funds													
Profit before Tax		-336	10,489	10,489	10,674	10,859	11,043	11,898	12,083	12,268	12,453	12,637	114,557
Depreciation		0	1,169	1,169	1,169	1,169	1,169	499	499	499	499	499	8,340
Funds from Operations		-336	11,658	11,658	11,843	12,028	12,212	12,397	12,582	12,767	12,952	13,136	122,897
Loan Drawdown		16,800											16,800
Equity Drawdown		11,200											11,200
Funds for allocation		27,664	11,658	11,658	11,843	12,028	12,212	12,397	12,582	12,767	12,952	13,136	150,897
Alloction of Funds													
Investment		27,000											27,000
Repayment		0	0	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	15,120
Paid Taxes		0	0	812	839	854	869	883	952	967	981	996	8,154
Paid Dividend		0	0	968	965	982	999	1,016	1,095	1,112	1,129	1,146	9,410
Total allocation		27,000	0	3,460	3,484	3,516	3,548	3,579	3,726	3,758	3,790	3,822	59,684
Changes Net Curr. Assets		664	11,658	8,198	8,359	8,512	8,665	8,818	8,856	9,009	9,162	9,315	91,213
Analysis of Changes													
Current Assets													
Cash at start of year		0	664	7,591	15,790	24,148	32,660	41,325	50,142	58,998	68,006	77,168	
Cash at end of year		664	7,591	15,790	24,148	32,660	41,325	50,142	58,998	68,006	77,168	86,483	
Changes in Cash		664	6,927	8,198	8,359	8,512	8,665	8,818	8,856	9,009	9,162	9,315	86,483
Debtor changes		0	7,811	0	0	0	0	0	0	0	0	0	7,811
Stock Movements		0	0	0	0	0	0	0	0	0	0	0	0
Changes in Current Assets		664	14,739	8,198	8,359	8,512	8,665	8,818	8,856	9,009	9,162	9,315	94,294
Liabilities													
Creditor changes		0	3,081	0	0	0	0	0	0	0	0	0	3,081
Changes Net Curr. Assets		664	11,658	8,198	8,359	8,512	8,665	8,818	8,856	9,009	9,162	9,315	91,213

Appendix 7: Profitability model – Balance sheet

Balance Sheet												
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Balance Sheet												
Assets												
Cash Account	0	664	7,591	15,790	24,148	32,660	41,325	50,142	58,998	68,006	77,168	86,483
Debtors (Acc Received)	20%	0	7,811	7,811	7,811	7,811	7,811	7,811	7,811	7,811	7,811	7,811
Inventory Stock	0	0	0	0	0	0	0	0	0	0	0	0
Current Assets		664	15,403	23,601	31,960	40,471	49,136	57,954	66,809	75,818	84,979	94,294
Fixed Assets		27,000	25,831	24,662	23,493	22,324	21,155	20,656	20,157	19,658	19,159	18,660
Total Assets		27,664	41,234	48,263	55,453	62,795	70,291	78,610	86,966	95,476	104,138	112,954
Debts												
Dividend Payable		0	968	965	982	999	1,016	1,095	1,112	1,129	1,146	1,163
Taxes Payable		0	812	839	854	869	883	952	967	981	996	1,011
Creditors (Acc Payable)	15%	0	3,081	3,081	3,081	3,081	3,081	3,081	3,081	3,081	3,081	3,081
Next Year Repayment		0	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680
Current Liabilities		0	6,541	6,565	6,597	6,629	6,660	6,807	6,839	6,871	6,903	6,934
Long Term Loans		16,800	15,120	13,440	11,760	10,080	8,400	6,720	5,040	3,360	1,680	
Total Debt		16,800	21,661	20,005	18,357	16,709	15,060	13,527	11,879	10,231	8,583	6,934
Equity		11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200
Profit & Loss Balance		-336	8,373	17,058	25,896	34,887	44,031	53,882	63,887	74,045	84,356	94,819
Total Capital		10,864	19,573	28,258	37,096	46,087	55,231	65,082	75,087	85,245	95,556	106,019
Debts and Capital		27,664	41,234	48,263	55,453	62,795	70,291	78,610	86,966	95,476	104,138	112,954

Appendix 8: Profitability model- Profitability measurements

Profitability													
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
Profitability Measurements													
NPV and IRR of Total Cash Flow													
Cash Flow after Taxes		0	8,775	12,694	12,667	12,652	12,637	12,623	12,554	12,539	12,525	12,510	**122,176**
Investment		-27,000											**-27,000**
Total Cash Flow & Capital		-27,000	8,775	12,694	12,667	12,652	12,637	12,623	12,554	12,539	12,525	12,510	**95,176**
NPV Total Cash Flow	15%	**-27,000**	**-19,369**	**-9,771**	**-1,442**	5,792	12,075	17,532	22,251	26,350	29,911	**33,003**	
IRR Total Cash Flow		0%	0%	0%	12%	25%	32%	36%	38%	40%	41%	**41%**	
NPV and IRR of Net Cash Flow													
Free (Net) Cash Flow		-336	6,927	9,166	9,324	9,494	9,664	9,834	9,950	10,120	10,290	10,460	**94,893**
Equity Part of Investment		-10,800											**-10,800**
Net Cash Flow & Equity		-11,136	6,927	9,166	9,324	9,494	9,664	9,834	9,950	10,120	10,290	10,460	**84,093**
NPV Net Cash Flow	15%	**-11,136**	**-5,112**	1,819	7,949	13,377	18,182	22,433	26,174	29,482	32,407	**34,993**	
IRR Net Cash Flow		0%	0%	27%	52%	63%	69%	72%	73%	74%	74%	**74%**	
Financial Ratios:													
ROI:(Profit+Interest/Debt+Capital)			45%	30%	26%	22%	20%	19%	17%	15%	14%	12%	
ROE: (Profit/Shared. Capital)			89%	49%	35%	27%	22%	20%	17%	15%	13%	12%	
TR: (Revenue/Debt+Capital)=Asset Turnover			141%	95%	81%	70%	62%	56%	50%	45%	41%	38%	
CR (Capital ratio) : (Capital/Debt+Capital)			47%	59%	67%	73%	79%	83%	86%	89%	92%	94%	
Net Current Ratio: (Current Asset/Current Liability)			2.4	3.6	4.8	6.1	7.4	8.5	9.8	11.0	12.3	13.6	
Liquid Current Ratio: (Current Asset - Inventory/Current Liabil			2.4	3.6	4.8	6.1	7.4	8.5	9.8	11.0	12.3	13.6	
Internal value of Shares: (Total Capital/Equity)			1.7	2.5	3.3	4.1	4.9	5.8	6.7	7.6	8.5	9.5	
Debt Service Coverage: (cash flow after tax/interest-LMF+rep			4.7	3.6	3.8	4.0	4.2	4.5	4.8	5.2	5.6	6.1	
Accepatable Minimum			1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	

Appendix 9: Profitability model - Sensitivity analysis

Deviations	Percentage	Cost of equipment (US$)	NPV of equipment	Sales quantity (kg)	NPV of sales quantity	Sales price (US$)	NPV of sales price (US$)	Variable cost (US$)	NPV of variable cost	Fixed cost (US$)	NPV of fixed cost
-50%	**50%**	2,175	36,856	2,350	-6,346	4.16	**-55,953**	10,264	81,785	2,506	46,738
-40%	**60%**	2,610	36,483	2,820	1,922	4.99	**-37,031**	12,316	72,426	3,007	44,389
-30%	**70%**	3,045	36,111	3,290	10,189	5.82	-18,108	14,369	63,068	3,508	42,040
-20%	**80%**	3,480	35,738	3,760	18,457	6.65	-206	16,422	53,709	4,010	39,691
-10%	**90%**	3,915	35,365	4,230	26,725	7.48	17,367	18,474	44,351	4,511	37,342
0%	**100%**	4,350	34,993	4,700	34,993	8.31	34,993	20,527	34,993	5,012	34,993
10%	**110%**	4,785	34,620	5,170	43,260	9.14	52,619	22,580	25,634	5,513	32,644
20%	**120%**	5,220	34,247	5,640	51,528	9.97	70,245	24,632	16,276	6,014	30,295
30%	**130%**	5,655	33,875	6,110	59,796	10.80	87,871	26,685	6,917	6,516	27,946
40%	**140%**	6,090	33,502	6,580	68,064	11.63	105,497	28,738	-2,441	7,017	25,596
50%	**150%**	6,525	33,129	7,050	76,331	12.47	123,123	30,791	-11,800	7,518	23,247

Appendix 10: Cost structure of semi-intensive shrimp farming systems in Asian countries, 1994 (ADB/NACA, 1996).

	Indonesia	Philippines	Malaysia	Vietnam	India	Sri Lanka	China
General							
Average farm size (ha)	2.0	7.5	2.1	1.4	6.4	2.5	24.5
Stocking density (PL/m^2)	20.7	15.5	39.0	11.5	24.3	28.8	19.7
FCR	1.4	1.7	1.9	0.3	2.4	1.9	2.1
Production (kg/ha/yr)	1,479	2,701	4,693	662	2,374	5,040	848
Cost (US$)							
Fixed cost (US$/kg)	0.82	0.34	1.59	1.11	1.62	0.96	0.76
Variable cost (US$/kg)	2.95	3.67	3.9	2.23	4.34	3.59	1.51
Total cost (US$)	3.78	4.01	5.5	3.34	5.96	4.56	2.27
Farm gate price (US$)	6.83	6.55	7.03	5.63	7.27	7.56	3.21
Profit (US$/kg)	3.05	2.54	1.53	2.29	1.31	3.00	0.94