Investment opportunities of small-scale *Penaeus vannamei* (Vannamei) shrimp farming in the Northwestern Province of Sri Lanka

W. A. A. M. Bandara*, K. H. M. L. Amaralal and V. S. Gunaratne

National Aquatic Resources Research and Development Agency (NARA), Crow Island, Colombo 15, Sri Lanka

Abstract

There has been an increasing interest in sustainable management of *Penaeus vannamei* shrimp farming in Sri Lanka since many years, yet little attention has been paid to the economic viability of farming systems. This study aims to assess the economic viability of small-scale *P. vannamei* shrimp farming in the Northwestern Province of Sri Lanka. The study examined 45 farms in year 2021 and revealed that it was a male-dominated small-scale industry and one hectare of land with 4047m2 of the pond incurred Rs. 5,720,360 (28,891 US$) of an initial capital investment and annual variable cost of Rs. 5,355,387 (27,047 US$). Further, an economic analysis revealed that the Net Present Value (NPV) of the capital invested by the end of nine years was Rs. 1,465,552 (7,402 US$) with a pay-back period of approximately 4 years while the Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR) were 16% and 1.04 respectively. All those factors indicated that farming systems were economically viable in the study area.

Keywords: Economic analysis, white-leg shrimp, *Penaeus vannamei*, shrimp farming

*Corresponding author- Email: ayomimenaka6@gmail.com

Introduction

Shrimp farming is one of the world's fastest-growing production systems (Emerenciano *et al*., 2022) and it contributes to the food security and livelihoods of the people in many regions of the word (Hossain *et al.*, 2013) as it fetches high value in the global market and emerges as one of highly profitable export products (Engle *et al*., 2017). Although traditional shrimp farming has a long history in Asia for centuries farming of penaeid shrimp species (Kungvankij, 1985) in commercial level has begun in the 1970s resulted in shrimp production has been growing steeply to cater the demand gaps (Biao and Kaijin, 2007). The global shrimp production in 2021 is set to be at least 8.9 % higher than 2020, and over 5 % growth is forecasted for the 2022 (FAO, 2021) and after 2007, the sector was dominated by farmed shrimp over the wild capture which accounts for 55 % of total shrimp produced globally (Stentiford *et al*., 2012). Among farmed shrimp, two warm - water species; Asian black or giant tiger shrimp (*Penaeus monodon*) and Pacific white shrimp (*Penaeus vannamei*) are dominated in the global context (*Glenn et al*., 2005; Christie, 2014; Liao and Chien, 2011) and account for roughly 80% to the total farmed shrimp production in the world (Rosenberry, 2001).

Sri Lanka initiated shrimp farming in the 1980's in Northern and Eastern parts of the country and it has been emerged as the second largest export species, in value terms, in exports of fish and fishery products of the country in recent years (Siriwardena 1999; and Gammanpila, 2014). At the very beginning farmers confined to culture *P. Monodon*, as a brackish-water monoculture, (Gammanpila, 2014) until an exotic and genetically improved (Alday-Sanz, 2020) Specific Pathogen Free (SPF) Pacific white shrimp (*Penaeus vannamei*) were introduced in 2018, as a solution for frequent crop failures of *P. monodon* due to the white spot disease (Munasinghe, 2010) and since then the annual production has been increasing and has contributed about 20 % to the total farmed shrimp production of the country in 2020.

Farming of *P. vannamei* has been rapidly expanding (FAO, 2009) around the world mainly due to many factors; availability of selectively bred SPF seeds with an increase in tolerance to a wide range of salinities (0 to 45 ppt), amenable for high stocking densities, rapid growth, column feeding habit and feeding on natural bio-flock, low dietary protein requirement (30-35%) and higher meat yield (65-70%) (Mathew *et al*., 2020; Ravichandran *et al*., 2009) were some of them. Despite these factors, small-scale

farmers in the Northwestern Province often claimed that productivity and profitability of *P. vannamei* farming system has been decreasing partly due socio-economic factors; lack of technical know-how in systematic farming and disease controlling, lack of institutional supports in the entire production process and high input costs were some of them. There were 1,012 farm systems with 4,347 ponds extended to 2,180 hectare of lands in the areas of Chilaw, Ambakandawila, Thoduwawa, Iranwila, and Muthupanthiya in the Northwestern Province by the end of 2019 and have produced 543 Mt of vannamei shrimp or contributed 8% percent to the total farmed shrimp produced in the country (MFARD, 2020) and therefore, this paper aims to examine the economic viability of small-scale *P. vannamei* farming systems in the Northwestern Province for the sustainability of shrimp farming industry of Sri Lanka.

Materials and Methods

Farming of *P. vannamei* is abundant in Ambakandawila, Thoduwawa, Iranwila and, Muthupanthiya areas in the Northwestern Province of Sri Lanka and therefore selected as the study area. All farms less than two hectares in size were considered as the study population according to the farm classification maintained by the National Aquaculture Development Authority (NAQDA) for its administrative purposes. In total 45 farms were randomly selected for the study and pre-tested structured questionnaires were administered to collect data on socio-economic and demographic factors. The respondents were farm owners. In addition to that one focus group discussion was conducted in each area with the participation of key informants and field observations were undertaken to verify the data given by respondents. Apart from that farm record books were used whenever required. All data were collected during the time period of January to July in 2021 and an integrated methodology was applied to analyse data and SPSS and Microsoft excel software packages were used whenever appropriate. The costs and benefits were calculated on one acre ($4047m^{2)}$ pond area. Results are presented using tables and charts whenever relevant. A model was developed for simulation of production, finance, cash flow, capital replacement, depreciation, and profitability with the annual values of the farms. In the analysis values related to the land, buildings, fencing and equipment were considered as initial investment of a farm while NPV was used to analyse the profitability;

$$NPV = \sum_{i=1}^{n} \frac{Cash\ Flow_i}{(1+r)^i} - Initial\ Investment$$

Where: r – discount or interest rate, n – the number of time periods, i – the cash flow period,

The following assumptions were also made; the financing of a farm was done through both the owner equity and an outside loan with a 10% interest and nine years pay-back period. All depreciation were estimated using the straight-line method and the percentages for buildings, equipment and fencing were 4, 10 and 20 percent respectively. A 10% discount rate was considered. All the inputs and output related to current study are based on price at the 2021 and US dollars (US$) exchange rate is 198 Rs/US$. The culture period of one cycle was considered as 4 months and only two cycles were operated per year. Secondary data of the study were collected from the Ministry of Fisheries and Aquatic Resources Development (MFARD), National Aquatic Resources Research and Development Agency (NARA), NAQDA, Sri Lanka Seafood Exporters' Associations and Shrimp Farmers' Associations in the respective areas.

Results and Discussion

Socio- economic characteristics of *P. vannamei* farmers

All farmers were male with a majority (42%) from the age group of 40-49 years old, while 56 % have engaged in shrimp farming over 10 years indicating that though most of farmers were middle aged but have long term experience. The four decades old shrimp farming industry supports almost all dwellers for their livelihood. Farmers used three major sources to get water into farming systems and of them lagoon (49%) was the major followed by Dutch Canal (40%) and tube wells (4%) but some farmers used both lagoon and tube wells (7%) (Table 1).

Table 1: Source of water for shrimp farms

Type of water source	Number of farms	Percentage (%)
Lagoon	22	49
Tube well	2	4
Dutch Canal	18	40
Both lagoon & tube well	3	7

Main reasons for the selection of water source were convenience and availability but farmers understood that using the lagoon and Dutch Canal waters may be a possible cause of infections of white spot disease and other waterborne pathogens.

Farm management settings

Present study revealed that a community-based management system was prominent in managing the farming activities in the areas. Farms were grouped into several zones and each zone was managed by small-scale farmers associations which were called *Samithiya*. All those community level associations collectively made decisions, involved in resolving issues and members met on monthly basis. Special meetings were also called whenever necessary in urgent matters. This management setting seemed successful in resolving issues related to the farming activities in the area and resulting in sharing a common pool of ecological resources in a meaningful way. Further, it enabled farmers to ensure better management of their resources. A zonal crop calendar system existed to manage and implement zonal and sub zonal level cycles, pond renovation, post-larvae stocking, and harvesting of resources. This management system gained momentum after the farming industry collapsed due to the white spot disease outbreak and resulted in several legal actions, as well as management practices being implemented specially with the introduction of SPF *P. vannamei* to the farming industry. NAQDA has introduced a set of better management practices and involved in the implementation of regulations and management specifications but community associations were responsible for frequent reporting on adherence to these Best Management Practices (BMP). BMP have been practiced on a basis of three categories of farms such as Grade A, Grade B, and grade C and were provided with specifications on stocking density, farm size, aeration,

post-larval transport, deposit, food management, water management, harvesting, record keeping, water management and treatment of the farm category.

Initial capital investment of farming systems

Shrimp farming required a higher level of initial capital investment and the result found that a total of Rs.5, 720,360 (28,891 US$) have been invested by a small-scale farmer and of them, the highest proportion was invested in land purchased and construction of earthen ponds (61%), fencing (12%) and permanent building (6%). Higher cost of fencing was recorded due to the specifically designed nylon nets to cover the culture ponds to protect from predators (Table 2).

Table 2: Investment cost for *P. vannamei* shrimp farm

Description	Value (Rs)
Cost of Land, buildings and Fencing	**4,520,000**
Land and ponds	3,500,000
Building	350,000
Fencing and nets	670,000
Cost of equipment	**1,200,360**
Refrigerator	130,000
Generator	250,360
Water pump	250,000
Paddle wheel	570,000

Variable costs of farming systems

Variable costs were production related short-term expenses, incurred in farming and varied based on scale of production which comprised mainly of seeds, feeds, chemicals, electricity and labour. Result found that feed had contributed to more than half (55%) of total variable cost. Chemicals and electricity cost are 15% and 9% respectively. The labour cost has contributed 9 % to the total variable cost of a farming cycle. The total variable cost of a farming cycle was estimated to Rs 2,677,693 (13,523 US$) and the annual variable cost of a farming system was Rs. 5,355,387 (27,047 US$) due to two

cycles were conducted per year. It was estimated that variable cost per kg of shrimp was Rs. 744 (3.76 US$) per cycle (Table 3).

Table 3: Variable cost of one culture cycle for one acre pond of *P. vannamei* farm

	Number of units	Unit cost (Rs.)	Total cost (Rs)
Labor (2×4 months)	8	30,420	243,360
Post Larvae	150,000	1.1	165,000
Feed	4,428	335	1,483,380
Electricity	23	10,500	241,500
Chemicals			400,000
Transport cost			25,000
Fuel			62,453
Harvesting charges			39,000
Other			18,000
Total Variable Cost			**2,677,693**

Production and Revenue

Results revealed that the total production of one acre (4047 m^2) pond area was 3,600 kg per one cycle which span for a period of 4 months and the total annual production was approximately 7,200 kg. The production varied on stocking density and rate of natural mortality of shrimp during the farm cycle. It was observed that maximum stocking density was 40 PL/m^2 and the average survival rate was 63 %. The initial average weight of a post larvae was 0.01 g and at the end of the culture cycle, it was on average 27 to 35 g (Table 4). The weight of a shrimp mainly depended on feeding and the status of hygiene management of the farm. The feeding amount and frequency varied through the growth dynamic of shrimp and result revealed that on average the feed conversation ratio was (FCR) 1.3 during the farm cycle.

Table 4: Price and quantity produced of one culture cycle

Description	Number of unit (kg)	Sales price (Rs)	Revenue (Rs)
Production	3,600	975	3,510,000

Financial Analysis of farming systems

Financial analysis of one farming cycle of small-scale farming system indicates in Table 5 and it depicts that the total cash flow was negative during the first year of farming cycle manly due to higher initial capital investment. However, after that the cash flow showed a positive value and at the end of 9 years it was Rs. 1,248,478 (6,305 US$) for a small-scale *P. vannamei* farm.

Table 5: Economic indicators for one culture cycle

Cost Item	**Value**
NPV (Rs.)	1,465,552
Pay Back (years)	4.6
Discounted Payback Period (years)	7.4
IRR (%)	16.13%
Benefit Cost Ratio	1.04

The financial viability of the farming system was estimated to Rs. 1,465,552 (7,402 US$) for the total capital invested in the farming system. The higher NPV value indicated that investing in *P. vannamei* shrimp farming was financially better off and financially viable. It could be said that small-scale *P. vannamei* farming was financially viable. It served as an incentive for new entries to the farming industry in the area. The Payback Period for total capital invested was estimated to be approximately four years which means that within a four year period invested money could be recovered. This value was highly positive, thus would attract new farmers. The Payback Period of an investment is the approximate return period of capital or business activities (Weingartner, 1969; Nguyen, 2012) and it indicates the number of years required to recover the initial capital investment from the net cash flow generating from the investment. Engle, (2017)

explained that aquaculture investments are preferred with the shortest Payback Period while other factors being equal because of risk considerations. In addition to that the discounted Payback Period was also calculated to assess the number of years after which the cumulative discounted cash inflow covers the initial investment in *P. vannamei* farming and found that it was 7.4 years.

Positive NPV value together with relatively a shorter Payback Period indicated that the investment in small scale *P. vannamei* farming in the area was highly motivated. Further, the Internal Rate of Return (IRR) was estimated to 16.13 % which was above the Minimum Attractive Rate of Return (MARR) of 10% at the end of 2021. It was obvious that invested in *P. vannamei* farming is more beneficial than invested in alternative business or saving in a bank. The IRR was calculated to analyse the interest rate at which capital could be borrowed for the farm or the interest that could be earned on capital invested (Tisdell, *et al*., 1993; Sureshwaran *et al*., 1994). The Benefit Cost Ratio (BCR) was estimated and it summarizes the overall relationship between the relative costs and benefits of the investment and if the ratio is greater than 1.0, the investment receives a positive Net Present Value while if the value is lower than 1.0, costs of investment outweigh the benefits (Boyd, *et al.*, 2017; Islam *et al.*, 2005) and the result of the study found that the BCR was 1.04 which indicated that investment in *P. vannamei* farming delivered a positive net present value and farmers were benefited from the investment. The BCR compares the present value of all benefits with that of the cost and investments of a project (Kusumastanto, 1996).

Conclusion

Small-scale shrimp farming in the Northwestern Province of Sri Lanka is a male dominant industry engaged by middle-aged people in the area with long term farming experiences. Although the initial capital investment of farming systems is high, operating of one hectare of a farm with a 0.4047 hectare sized pond generates a NPV which reveals the revenue of a farm system is greater than cash outflows resulting in net profits of the *P. vannamei* farming. Further, shorter the Payback Period of capital investment, gives rise an economic incentive which persuades new investment into the industry which may lead further intensification of *P. vannamei* farming in the area. In practicing BMP and strictly confined to the SPF strains of *P. vannamei* together with appropriate hygienic

practices in farming, the farmers can overcome the vulnerability of cash flow in the farming system by ensuring economic as well as environmental sustainability of *P. vannamei* farming in the Northwestern Province of Sri Lanka.

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