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RESEARCH ARTICLE

Economic Performance of Aquaculture Farming in Nepal

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ABSTRACT

Although Nepal is a landlocked nation, its fisheries and aquaculture sub-sector plays a key role in the national economy. The study also analyzes the economic profitability of carp aquaculture farming in Nepal by using benefit-cost ratio, net present value, and internal rate of return. Data were collected from a sample of 150 farmers of five different districts representing three provinces using a questionnaire survey. All the economic parameters had been referred to a unit area (one hectare) to compare the cost of production and profitability. Results show that carp farming is profitable across all five districts, with Benefit-Cost Ratios ranging from 1.21 to 1.54 and Dhanusa recording the highest profitability (35.12% margin and Rs. 523,563.11 profit/hectare). Feed constitutes the largest variable production cost across all regions (31.00–45.52% of total costs), followed by labor and interest. Sensitivity analysis indicated that the aquaculture production systems are very sensitive to changes in market conditions.

Key words: B:C ratio, fish agribusiness, internal rate of return, etc.

INTRODUCTION

Though Nepal is a small landlocked country and has no major contribution to world fish production, the fisheries and aquaculture sector within the country plays a key role in the national economy in terms of Gross Domestic Product (GDP) contribution and employment. The agriculture sector shares 27.6% of the country's total GDP (Economic Survey, 2017/18) and within the agricultural sector, the fisheries and aquaculture sector contributes about 4.18% to the agricultural GDP and 1.13% to the national GDP (CFPCC, 2018). The fisheries and aquaculture sub-sector experienced a double-digit growth rate (Wagle *et al*., 2011) in the past few years due to increasing demand for fish products and changing food habits of the people. Nepalese aquaculture is predominantly small-scale and generally cultured in cages, ponds, and irrigated rice fields. Both warm-water (carps-Indian major carps and Chinese carps) and cold-water (Rainbow trout) species of fishes are found, as it has advantages of varied climate from tropical to arctic type. Mostly, the farmers in the terai (plain) and hilly areas have been shifting their production from rice and maize farming, respectively, to fish farming due to higher profitability from fish farming. The average production of rice and maize in Nepal is about 3.76 and 2.84 ton/ha/crop, respectively (MoALD, 2020). Carp polyculture is a profitable venture in Nepal. However, it is affected by a number of factors like environmental and natural factors, production technologies, farming system, and intensity of input use (Guziur, 2009), and economic factors like market demand and price level (Turkowski *et al*., 2010). For the aquaculture business to be

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sustainable, it depends on production technology, social and economic impacts, and environmental and climatic influences, which are interrelated (Grillone *et al*., 2014). Efficient farm management techniques involve not only the biological activities but also careful attention to its economic and financial measures for the success of the business. The efficient management of the farm can make a profit even in years of unfavorable prices and costs (Engle, 2010). Profit is a financial benefit that is realized when the amount of revenue gained from a business activity exceeds the expenses, costs, and taxes needed to sustain the activity. The economic performance of any farm can be evaluated using various financial indices such as benefit-cost analysis, net present value (NPV) and internal rate of return (IRR) (Kim *et al*., 2012; Di Trapani *et al*., 2014).

The effective use of business management tools, such as planning, controlling, and monitoring through effective budgeting, accounting, marketing, and financing, is important to improve farm performance in aquaculture (Engle, 2010) and agriculture (Kay *et al*., 2008; Nuthall, 2010). Capital budgeting, cash flow analysis, and investment analysis are the basic tools in financial management of the farm (Engle, 2010). There are various methods to evaluate the economic performance of farms, particularly in aquaculture; profitability, liquidity, and solvency are the most common measures to assess the financial performance (Menezes *et al*., 2017).

Investors always look for the information on the economic viability of the business before making any important investment decision. It is unfortunate that such information is lacking in Nepal. However, some studies were carried out regarding the cost-benefit analysis of the aquaculture business by Sharma *et al*. (2018) in Chitwan and by Adhikari *et al*. (2019) in Bara districts. This study emphasizes calculating the revenues and expenses of the current culture period and the NPV and IRR of the 10-year cash flow to determine the economic viability of carp farming in Nepal. The estimation of yield is dependent on the inputs used and the efficiency of input use. Hence, it is necessary to determine which factor/input variable is most important in influencing yield and the production function. Sensitivity analysis is the method to determine the effect of input variables on the output variable. The objective of this study was to analyze the economic performance of aquaculture farming in Nepal.

MATERIALS AND METHODS

Site Selection

Aquaculture is concentrated in the Terai region of Nepal; five Terai districts, namely, Jhapa, Morang, Sunsari, Dhanusa and Rupandehi were selected for the study. Dhanusa, located in the central-east part of the country representing Madesh Province, and Rupandehi, located in mid-western part of the country representing Lumbini Province, are the potential districts for aquaculture production and are considered as "Fish Superzone" by the Prime Minister Agriculture Modernization Project (PMAMP), Nepal. Morang, Sunsari, and Jhapa are located in the south-eastern part of the country, representing Koshi Province, and have a significant contribution to aquaculture production. Morang and Sunsari districts are also considered as "Fish Zone" by PMAMP, Nepal. The map with selected districts is presented in [Figure 1] below.

Method of Data Collection

A pilot survey was carried out with five farmers of Morang district to validate the developed questionnaire. Afterward, a household survey was conducted from March 2020 to June 2020, adopting a random sampling method. In total, 150 persons (30 persons from each district) were interviewed and asked about their opinions towards inputs, outputs, and overall farm economics.

Economic Analysis

All the economic parameters had been referred to unit area (one hectare) to compare the cost of production and profitability between different districts representing three provinces. The summation of total variable cost and total fixed cost incurred in the production process gives the total cost of production. The cost incurred for labor (permanent and temporary), fingerlings, feed, manure and fertilizers, fuel and energy, and miscellaneous expenses were considered as variable

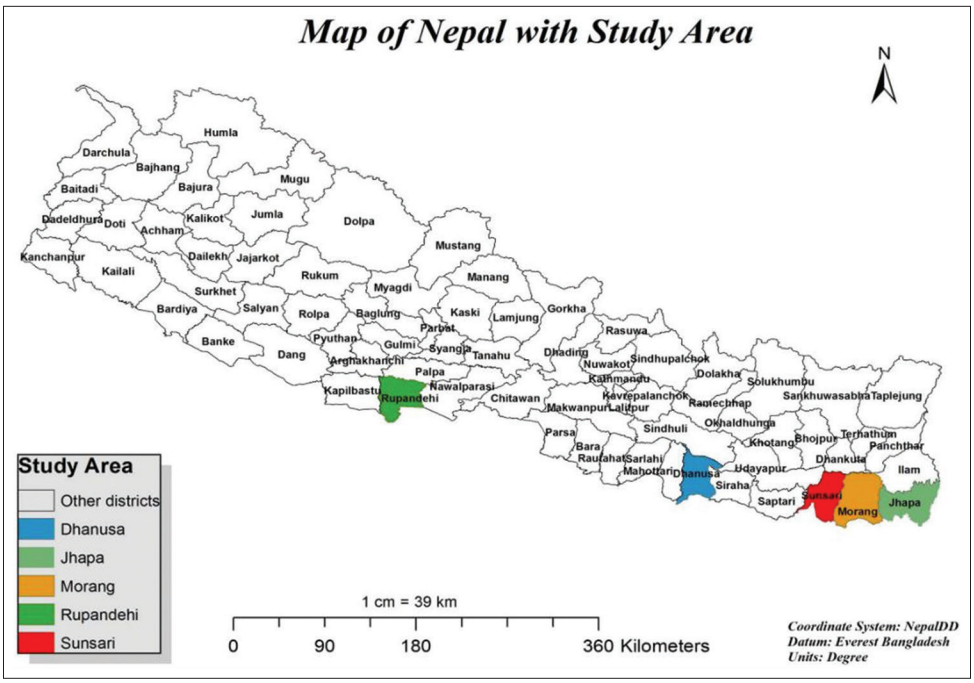


Figure 1: Map of Nepal indicating survey districts

cost. Land rent per year, depreciation on ponds and depreciation of farm tools, machinery and equipment, and interest on initial investment were considered as fixed costs. Interest was charged at the rate of 12% according to the prevailing interest rate. The depreciation on fish pond was calculated assuming 20 years of economic life of fish pond. It is in line with the aquaculture industry practices in Nepal and other similar countries and the appraisal report of the Second Aquaculture Development Project in Nepal. Furthermore, the depreciation was charged at the rate of 10%/annum on average for different equipment and machinery used in fish farms such as pipes, motor, pump set, generator, boring, aerator, fishing net, and farm buildings (Adhikari *et al*., 2019; CFPCC, 2018/2019). The total profit was calculated by deducting total cost from the total revenue, and the profitability percentage was calculated using the following formula;

$$\text{Profitability (\%)} = \frac{\text{Total profit}}{\text{Total revenue}} \times 100$$

The benefit-cost ratio was calculated for the economic analysis of the aquaculture farms in each district by dividing the total revenue by total costs. Benefit-cost ratio (BCR) is one of the most widely used indicators in capital budgeting to determine the financial desirability of the investment (Kahraman, 2001). Any investment is said to be profitable if BCR is greater than one (Oladejo and Ofoezie, 2006). The financial indicators, NPV and IRR, were employed to determine the suitability of the investment. The formula for NPV is as follows;

$$NPV = \sum_{t=0}^{n} \frac{C_t}{(1+r)_t}$$

Where, Ct represents the discounted annual cash flows; t is the time of the cash flow; n corresponds to the lifetime of the investment; and r is the discount rate. The discounted cash flows generated from each investment have been calculated for 10 years, equal to the life cycle of the investment. The discount rate was assumed to be 12% as per the bank interest rate. The suitability of the investment is assessed using NPV; the greater the value of NPV, the higher the suitability of the investment (Zuniga-Jara and Goycolea-Homann, 2014). The discounted annual cash flows were calculated by deducting cash outflows (total cost: Initial investment cost and production cost) from cash inflows (annual benefits). Annual benefits consisted the revenues obtained from the harvest of the fish, which are calculated by multiplying the total quantity produced from the farm by the unit cost. The investment period was 1 year. Production costs included all monetary costs:

feed, fingerlings, fuels and electricity, manure and fertilizers, labor, medicines, veterinary and other services, and maintenance cost.

The IRR is the discount rate at which NPV is zero; that means the discounted benefits are equal to the discounted costs. Any project or the farm business is worth investing if its IRR is greater than the predetermined reference discount rate (Tudisca *et al*., 2013). The IRR is calculated using the formula;

$$\sum_{t=0}^{n} \frac{C_t}{(1+r)^t} = 0$$

The farmers' choice either to adopt a new technology or not depend upon how much economic returns he can make from the particular business and it consequently affects their resource management decisions (Nyekanyeka, 2011). While cost and return analysis measures the success and failure of farm business (Kay and Edward, 1994), estimation of the production function identifies inputs that influence yield and shows the efficiency of input use (Shang, 1981).

Sensitivity analysis was carried out for all five districts to assess the effect of variation or fluctuation in input variables to the output variable. In this study, the sale price of fish, cost of feed, cost of fingerlings, and initial investment cost were chosen as parameters to be factored in sensitivity analysis to know their impact on NPV and IRR.

RESULTS AND DISCUSSION

Cost of Production and Profitability of Aquaculture Farms

The sustainability of the aquaculture farming depends on the technical proficiency, socioeconomic impacts, and environmental influences. All these factors are interrelated (Agnese *et al*., 2008; Edwards *et al*., 1997; Grillone *et al*., 2014). If the fish farm is technically proficient but not economical in commercial aspect, it is of no use (Tisdell, 2001). The cost of production per hectare per year and the economic performance of five districts are presented in Table 1.

In aquaculture farms of Jhapa, the average cost of production per hectare was found to be Rs. 1,158,842.72, the investment cost was Rs. 1,109,712.23, and the revenue from the harvest of fish was Rs. 1,447,248.98, with profitability of 19.93%. Among the input variables, feed represented 37.06% of the total production costs, followed by labor cost, 16.79%; interest on capital, 11.49%; land rent, 9.55%; and manure and fertilizers, 7.17%.

In aquaculture farms of Morang, the average cost of production per hectare was found to be Rs. 1,009,051.60, the investment cost was Rs. 1,140,062.69, and the revenue from the harvest of fish was Rs. 1,274,927.71, with profitability of 20.85%. Among the input variables, feed represented 31.00% of the total production costs, followed by labor cost, 17.96%; interest on capital, 10.75%; manure and fertilizers, 8.68%; and land rent, 7.62%. The average cost of production per hectare in Sunsari districts was found to be Rs. 1,046,603.12; the investment cost was Rs. 937,334.09; and the revenue from the harvest of fish was Rs. 1,292,402.47, with profitability of 19.02%. Among the input variables, feed represented 31.95% of the total production costs, followed by labor cost, 17.96%; interest on capital, 10.75%; land rent, 10.30%; and manure and fertilizers, 8.36%. The average cost of production per hectare in Dhanusa districts was found to be Rs. 967,096.08, the investment cost was Rs. 864,314.68, and the revenue from the harvest of fish was Rs. 1,490,659.19, with profitability of 35.12%. Among the input variables, feed represented 45.52% of the total production costs, followed by land rent, 12.48%; labor cost, 11.17%; interest on capital, 10.72%; and manure and fertilizers, 7.44%. In Rupandehi district, the average cost of production per hectare was found to be Rs. 1,227,535.43, the investment cost was Rs. 1,078,592.95, and the revenue from the harvest of fish was Rs. 1,489,777.26, with profitability of 17.60%. Among the input variables, feed represented 35.51% of the total production costs, followed by labor cost, 21.91%; interest on capital, 10.54%; land rent, 8.95%; and manure and fertilizers, 7.97%.

The investment cost and average cost of production of fish farming per hectare were found to be lowest, and the revenue was found highest, with the highest profitability of 35.12% for Dhanusa district. The most important driver of profitability for Dhanusa is low production cost due to low labor cost and high farm gate price for Janakpur's fish. Janakpur

Table 1: Costs and profitability of carp species per hectare per year for five different districts

Variables	Jhapa	% of total cost	Morang	% of total cost	Sunsari	% of total cost	Dhanusa	% of total cost	Rupandehi	% of total cost
Production parameters										
Fry/Fingerlings (Number)	15034.85		14991.70		15026.55		15616.42		15403.74	
Survival Rate (%)	0.68		0.66		0.67		0.68		0.67	
Final Weight (kg)	0.56		0.56		0.56		0.53		0.57	
Market Price (Rs/kg)	253.00		232.67		228.17		263.17		253.50	
Culture cycle (months)	10		10		10		10		10	
Production Amount (kg)	5720.35		5479.63		5664.29		5664.32		5876.83	
Production Value (Rs) Total Revenue (TR)	1447248.98		1274927.71		1292402.47		1490659.19		1489777.26	
Capital cost (Initial investment cost)	1109712.23		1140062.69		937334.09		864314.68		1078592.95	
Pond construction	923670.25		943308.13		838737.20		793388.71		861057.54	
Farm equipment	186041.98		196754.56		98596.89		70925.97		217535.40	
Fixed costs										
Depreciation	65971.22	5.69	66840.86	6.62	51796.55	4.95	46762.03	4.84	64806.42	5.28
Land rent	110690.86	9.55	76846.60	7.62	107761.34	10.30	120718.30	12.48	109878.73	8.95
Interest (12%)	133165.47	11.49	136807.52	13.56	112480.09	10.75	103717.76	10.72	129431.15	10.54
Variable costs										
Permanent labor	194514.39	16.79	195390.01	19.36	187940.84	17.96	107989.25	11.17	268996.69	21.91
Temporary labor	34916.30	3.01		0.00	22753.13	2.17	7168.34	0.74	9267.85	0.75
Feed	429460.43	37.06	312830.54	31.00	334373.81	31.95	440230.29	45.52	435881.74	35.51
Fry/Fingerlings	39739.77	3.43	38408.17	3.81	38228.10	3.65	24146.10	2.50	44772.52	3.65
Manure and fertilizers	83122.59	7.17	87552.46	8.68	87467.77	8.36	71941.87	7.44	97826.63	7.97
Fuel and Energy	44464.93	3.84	32048.31	3.18	34944.82	3.34	31280.19	3.23	28256.70	2.30
Miscellaneous	22796.76	1.97	62327.13	6.18	68856.66	6.58	13141.95	1.36	38416.99	3.13
Total cost (TC) (Rs.)	1158842.72	100.00	1009051.60	100.00	1046603.12	100.00	967096.08	100.00	1227535.43	100.00
Profit (Rs.) (TR-TC)	288406.26		265876.11		245799.35		523563.11		262241.83	
Profitability (%)	19.93		20.85		19.02		35.12		17.60	
Benefit cost ratio (BCR)	1.25		1.26		1.23		1.54		1.21	
Cost per kg (Rs.)	202.58		184.15		184.77		170.73		208.88	
Profit per kg (Rs.)	50.42		48.52		43.39		92.43		44.62	

is the sub-metropolitan city of Dhanusa district. This observation is in line with the concept of Engle (2010), who stated that lower production costs can yield higher profits. Among five districts, Dhanusa has a high human poverty index (41.72) and a low human development index (0.431) (NPC and UNDP, 2014). Due to the poor condition of people, the labors are easily available at low wage rate thereby reducing the labor cost and hence the production cost. There is wider acceptance of Janakpur's fish in domestic as well as Indian markets due to its freshness and good quality. The results revealed that the fish supply chain is from input suppliers through production to the consumption level, in which fish farmers channel their produce directly to the local market through retailers, and for Indian consumers, Indian traders channel the produce to Indian consumer from fish farmers, hence giving farmers a better farm-gate price. Farheen *et al*. (2019) also indicated that the producers' share was highest for the short marketing channel and decrease with an increase in the number of intermediaries in the marketing channel. However, they also practice a long supply chain in which fishermen or local traders channel their produce to collectors, then to wholesalers and processors, and finally the consumers. In Koshi corridor, which consists of Morang and Sunsari districts, producers channel their produce through fish collectors, local traders, wholesalers, and retailers en route to the consumers (MoICS, 2018). The farm gate price will be low if the chain grows longer because there should be some fair cost price to make considerable profits to each level, and meanwhile, consumers should not be the only one bearing huge economic load. Phiri and Yuan (2018) reported that the tilapia farmers of Malawi received high farm gate price compared to farmers of China as Malawi farmers fish supply chain is shorter than China.

There is no government hatchery in Province no. 1, and in private hatchery the cost of fingerlings is generally high. This is one of the reasons that production cost is high for the districts in Province no. 1. Hence, it is necessary to build at least one government hatchery in Province no. 1 so that farmers could get the seed in reasonable price. The fisheries policy needs to be formulated and implemented to regulate the private hatcheries so that they will provide the seeds in the required quantity in proper time in reasonable price.

Among the input variables, in all districts, feed accounted for the highest cost of the total production cost, followed by labor cost. This result is in line with other various studies (Phiri and Yuan, 2018; Di Trapani *et al*., 2014; Bozoglu and Ceyhan, 2009; Turkowski and Lirski, 2010). Feed was actually the highest contributor to total cost, and this high cost of feed can be attributed to the recent global economic conditions, which have impacted the production costs of most enterprises. Feed cost and labor cost are the major input variables that contribute to the higher cost to total cost of production in carp polyculture in Chitwan and Bara districts of Nepal (Sharma *et al*., 2018; Adhikai *et al*., 2019) and in red sea bream Pagrus major offshore aquaculture production system in Korea (Kim *et al*., 2012). Nepal has experienced a surge in out-migration for foreign employment to various destination countries over the past decade (MoLESS, 2020), which results in the shortage of labor in the home country. It is difficult to get the required number of labors in time, if available also they charge high wage rate. Still, the country's aquaculture sector is not fully commercialized and mechanized to accomplish the production cycle with minimum labors. This has become one of the greatest threats in Nepalese aquaculture sector.

Economic Performance of the Aquaculture Farms of Selected Districts

The economic performance of the farms was evaluated using financial indicators, viz. NPV and IRR [Table 2]. The NPV and IRR of Dhanusa district were significantly higher in comparison with other districts. In particular, Dhanusa district's NPV was equal to Rs 2,093,933.63 with an IRR of 60.03%. The difference in NPV might be due to the high revenues value of Rs. 1,490,659.19 per hectare in Dhanusa. As Dhanusa is famous for the aquaculture since many years and there is like a brand of "Janakpur's fish" thereby making the market price of fish little bit higher than other districts. As, Nepal has an open border with India, every year tonnes of fish are imported formally or informally. Fishes from India, though cheap, are not preferred by consumers as it has been ice-packed

Table 2: Cash flow, NPV and IRR of the fish production in five selected districts

Year	Jhapa			Morang			Sunsari		
	Revenue	Costs	Net benefit	Revenue	Costs	Net benefit	Revenue	Costs	Net benefit
0	0.00	1109712.23	−1109712.23	0.00	1140062.70	−1140062.70	0.00	937334.09	−937334.09
1	1447248.98	1158842.72	288406.26	1274927.71	1009051.60	265876.11	1292402.47	1046603.12	245799.35
2	1447248.98	1158842.72	288406.26	1274927.71	1009051.60	265876.11	1292402.47	1046603.12	245799.35
3	1447248.98	1158842.72	288406.26	1274927.71	1009051.60	265876.11	1292402.47	1046603.12	245799.35
4	1447248.98	1158842.72	288406.26	1274927.71	1009051.60	265876.11	1292402.47	1046603.12	245799.35
5	1447248.98	1158842.72	288406.26	1274927.71	1009051.60	265876.11	1292402.47	1046603.12	245799.35
6	1447248.98	1158842.72	288406.26	1274927.71	1009051.60	265876.11	1292402.47	1046603.12	245799.35
7	1447248.98	1158842.72	288406.26	1274927.71	1009051.60	265876.11	1292402.47	1046603.12	245799.35
8	1447248.98	1158842.72	288406.26	1274927.71	1009051.60	265876.11	1292402.47	1046603.12	245799.35
9	1447248.98	1158842.72	288406.26	1274927.71	1009051.60	265876.11	1292402.47	1046603.12	245799.35
10	1447248.98	1158842.72	288406.26	1274927.71	1009051.60	265876.11	1292402.47	1046603.12	245799.35
		r	12%		r	12%		r	12%
		NPV	519847.47		NPV	362196.62		NPV	451487.08
		IRR	22.60%		IRR	19.34%		IRR	22.88%

Dhanusa			Rupandehi		
Revenue	Costs	Net benefit	Revenue	Costs	Net benefit
0.00	864314.68	−864314.68	0.00	1078592.95	−1078592.95
1490659.19	967096.08	523563.11	1489777.26	1227535.43	262241.83
1490659.19	967096.08	523563.11	1489777.26	1227535.43	262241.83
1490659.19	967096.08	523563.11	1489777.26	1227535.43	262241.83
1490659.19	967096.08	523563.11	1489777.26	1227535.43	262241.83
1490659.19	967096.08	523563.11	1489777.26	1227535.43	262241.83
1490659.19	967096.08	523563.11	1489777.26	1227535.43	262241.83
1490659.19	967096.08	523563.11	1489777.26	1227535.43	262241.83
1490659.19	967096.08	523563.11	1489777.26	1227535.43	262241.83
1490659.19	967096.08	523563.11	1489777.26	1227535.43	262241.83
1490659.19	967096.08	523563.11	1489777.26	1227535.43	262241.83
	r	12%		r	12%
	NPV	2093933.63		NPV	403131.88
	IRR	60.03%		IRR	20.57%

NPV: Net present value, IRR: Internal rate of return

for a long time and people usually prefer fresh or live fish. Hence, people prefer Nepalese fish over Indian fish and ready to pay more for Nepalese fish. The price difference of Nepalese and Indian fish is about Rs. 40 per kg as revealed by the study of Farheen *et al*. (2019).

Almost all the aquaculture farms have positive NPV except a few. In general, the small farms of pond area <0.20 hectare of Sunsari and Morang districts showed negative NPV. It might be due to high cost and small scale of production. Actually, they don't consider the family labor as paid labor and it seems like profitable in short run but in long term it is not worthwhile. This result is in line with the studies of Zoran *et al*., 2016. They reported that intensive carp farming in small areas of Serbia was not economically justifiable. However, the results, in general, showed that the farmers are gaining income from their farm regardless of the farm size (either big or small farm or ponds), which is in line with the previous studies (De Bezerra *et al*., 2016; Zhang *et al*., 2016). Since, the benefit cost ratio of all the five districts showed the value greater than one indicating that the carp farming is profitable depending upon the investment level and cost. The similar results were reported by Turkowski and Lirski (2010) on carp in Hungary and Germany, but contrasting results in Poland; Elhendy and Alzoom (2001) on Tilapia in Saudi Arabia; El-Naggar *et al*. (2008) in Egypt; and Kudi *et al*. (2008) in Nigeria,

who also indicated the profitability of fish farms. Engle and Niera (2005) also reported that the tilapia farms in Kenya were profitable, with positive net returns, and the cash flow budget also showed a positive cash flow balance, indicating that the business plan is feasible.

Sensitivity Analysis

Sensitivity analysis was carried out to determine the influence of the input variables on output variables. For the input variables, I selected the sale price of fish, feed cost, fingerling costs, and initial investment costs, and for the output variables, I selected NPV and IRR. Each input variable has been varied by 5%, 10%, and 15% above and below its baseline value to find the new financial indices for each district. The variation of input variables was chosen taking into account the volatility of prices that occurred in the last 3 years, as per the view of surveyed farmers. The result of sensitivity analysis is presented in Table 3.

The simulations indicated that just a reduction of 5% of the current fish price caused a big change on financial indicators (NPV and IRR) in all districts, while a decrease of 15% would cause worsening of the financial indicators. In particular, sales price of fish variation by ± 5–± 15% from baseline value caused the variation of NPV ranged from ± 24.85% to ± 74.86%, ± 23.81 to ± 71.42%, ± 26.46 to 79.39%, ± 14.30 to ± 42.91% and ± 28.05 to ± 84.14% in Jhapa, Morang, Sunsari, Dhanusa and Rupandehi

Table 3: Sensitivity analysis of aquaculture production systems in five selected districts

Parameter	% change	Jhapa		Morang		Sunsari		Dhanusa		Rupandehi	
		NPV	IRR (%)	NPV	IRR (%)	NPV	IRR (%)	NPV	IRR (%)	NPV	IRR (%)
Initial investment	−15	1811471.02	50.84	1683864.83	47.45	1520286.844	50.61	3073825.238	91.61	1662406.422	48.86
	−10	1755985.408	47.84	1626861.695	44.62	1473420.139	47.62	3030609.504	86.48	1608476.774	45.95
	−5	1700499.797	45.13	1569858.56	42.06	1426553.435	44.93	2987393.77	81.88	1554547.127	43.33
	Baseline	1645014.19	42.68	1512855.43	39.73	1379686.73	42.48	2944178.04	77.74	1500617.48	40.95
	+5	1589528.574	40.44	1455852.291	37.61	1332820.026	40.25	2900962.301	73.98	1446687.832	38.79
	+10	1534042.962	38.39	1398849.156	35.67	1285953.321	38.21	2857746.567	70.56	1392758.184	36.80
	+15	1478557.351	36.50	1341846.021	33.88	1239086.616	36.33	2814530.833	67.42	1338828.537	34.97
Sale price of fish	−15	418422.2538	20.64	432311.539	20.69	284332.401	19.02	1680794.507	51.29	237981.4095	17.18
	−10	827286.2309	28.35	792492.8345	27.32	649450.5107	27.27	2101922.35	60.19	658860.0994	25.59
	−5	1236150.208	35.64	1152674.13	33.63	1014568.62	35.03	2523050.192	69.00	1079738.789	33.44
	Baseline	1645014.19	42.68	1512855.43	39.73	1379686.73	42.48	2944178.04	77.74	1500617.48	40.95
	+5	2053878.162	49.55	1873036.721	45.69	1744804.84	49.75	3365305.878	86.44	1921496.169	48.27
	+10	2462742.139	56.32	2233218.016	51.55	2109922.95	56.90	3786433.721	95.11	2342374.859	55.45
	+15	2871606.116	63.02	2593399.312	57.33	2475041.059	63.97	4207561.564	103.77	2763253.549	62.55
Feed cost	−15	2008996.268	48.80	1777989.771	44.13	1663079.725	48.14	3317287.936	85.45	1870041.837	47.38
	−10	1887668.907	46.77	1689611.656	42.67	1568615.393	46.26	3192917.969	82.88	1746900.384	45.25
	−5	1766341.546	44.73	1601233.54	41.21	1474151.062	44.38	3068548.002	80.31	1623758.932	43.11
	Baseline	1645014.19	42.68	1512855.43	39.73	1379686.73	42.48	2944178.04	77.74	1500617.48	40.95
	+5	1523686.824	40.61	1424477.31	38.25	1285222.399	40.57	2819808.069	75.16	1377476.026	38.78
	+10	1402359.463	38.52	1336099.195	36.76	1190758.067	38.65	2695438.102	72.58	1254334.574	36.59
	+15	1281032.102	36.42	1247721.08	35.26	1096293.736	36.71	2571068.135	70.00	1131193.121	34.37
Fingerling cost	−15	1678694.97	43.25	1545407.633	40.28	1412086.324	43.13	2964642.666	78.16	1538563.689	41.62
	−10	1667468.042	43.06	1534556.897	40.10	1401286.459	42.91	2957821.122	78.02	1525914.952	41.40
	−5	1656241.113	42.87	1523706.161	39.91	1390486.595	42.70	2950999.579	77.88	1513266.216	41.18
	Baseline	1645014.19	42.68	1512855.43	39.73	1379686.73	42.48	2944178.04	77.74	1500617.48	40.95
	+5	1633787.257	42.49	1502004.689	39.55	1368886.866	42.26	2937356.492	77.60	1487968.742	40.73
	+10	1622560.328	42.30	1491153.953	39.37	1358087.001	42.05	2930534.949	77.46	1475320.006	40.51
	+15	1611333.4	42.10	1480303.217	39.19	1347287.136	41.83	2923713.405	77.31	1462671.269	40.29

NPV: Net present value, IRR: Internal rate of return

respectively. If the market price increases by 15%, the NPV increases from by almost 85% (the highest among 5 districts) in Rupandehi, demonstrating the high influence of market price on profitability. Similarly, IRR varied from 20.64 to 63.02%; 20.69 to 57.33%, 19.02 to 63.97%, 51.29 to 103.77% and 17.18 to 62.55% in Jhapa, Morang, Sunsari, Dhanusa and Rupandehi, respectively. The similar results were also reported by Kim *et al*. (2012), which showed that the changes in market price caused a considerable variation in profitability; that is, 20% increase in the market price of red sea bream increases the NPV by 129% in offshore aquaculture production in Korea.

The variation in feed costs showed a considerable effect on the economic profitability of the aquaculture farms in all districts [Table 3]. However, the level of variation varies among districts. Among the five districts, Dhanusa exhibited a less variation in NPV (between ±4.22 and ±12.67%) and IRR (ranged from 70 to 85.45%), whereas Rupandehi showed large variation in NPV (±8.21–±24.62%) and IRR (ranged from 34.37% to 47.38%) due to changes in feed costs. The financial indicators experienced some changes due to changes in initial investment costs. In all districts, except Dhanusa, simulation showed a variation of approximately ±3.5–11% in NPV, whereas in Dhanusa, the difference varies from ±1.5 to ± 4.4%. IRR varied from 36.5 to 50.84%, 33.88 to 47.45%, 36.33 to 50.61%, 67.42 to 91.61%, and 34.97 to 48.86% in Jhapa, Morang, Sunsari, Dhanusa, and Rupandehi, respectively.

Sensitivity analysis showed a less effect of fingerling costs variation to the economic profitability of the farms in all districts. Specifically, there is only about < ±3% variation in NPV and less than 1 % variation in IRR in all districts due to a change in fingerling costs by 5–15% from the baseline value [Table 3]. In a nutshell, aquaculture farming is very sensitive to change in sales price of the fish, indicating a large influence on profitability in comparison to other parameters. The similar results were also presented on various studies (Hart *et al*., 2013; Di Trapani *et al*., 2014). There will be heavy reduction in the profitability of carp aquaculture if the market price decreases due to bumper production or high market competition. Therefore, it is highly necessary for the fish farmers to make appropriate marketing and production strategies to avoid a decrease in sale price and maintain desirable profitability of the farm. Commercial aquaculture is highly vulnerable to changes in market conditions, as it greatly depends upon commercial feed and machinery and equipment. The price of inputs may increase with an increase in the price of raw materials in the international market or any hindrances in the supply chain. Farmers in developing countries like Nepal should think of low-cost technology that utilizes local resources in order to reduce production cost and maximize profit.

CONCLUSION

The study concludes that carp aquaculture in Nepal is highly profitable, demonstrated by strong financial metrics including a NPV of Rs 2,093,933.63 and an IRR of 60.03%. This profitability is primarily driven by high stocking densities, high survival rates, low labor costs, and favorable market prices for fish. While large-scale farming shows the greatest profit potential when capital and inputs are available, small-scale producers can successfully expand operations by adopting semi-intensive systems, utilizing local resources, and improving farm management practices.

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