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Transformation of Rice Farming to Commercial Farming in Mymensingh: An Empirical Evidence Based on Farmer's Livelihood Patterns

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Abstract

The research aimed to compare the financial profitability of rice farming with diversified commercial farming, including crops, fisheries, livestock, and poultry, and examine the impact of transitioning rice farms to diversified ventures on farmers' livelihood patterns. Primary data were collected from 120 households in Mymensingh Sadar and Muktagacha Upazilas, with 40 respondents being rice farmers and 80 engaged in commercial farming. Both qualitative and quantitative methods were used, employing econometric models (focusing on the chi-square test) and descriptive statistics. The study disclosed net returns for fish, livestock, poultry, and rice farming, amounting to 29,25,157 Tk./ha, 3,90,055 Tk./farm, 2,83,193 Tk./farm, and 42,188 Tk./ha, respectively. The undiscounted benefit-cost ratios (BCR) for fish, livestock, and poultry farming were 1.78, 1.34, and 1.33, surpassing the BCR of rice farming, which was 1.25. The study also revealed enhancements in farmers'

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human, social, natural, physical, and financial capital from transforming rice farms into commercial enterprises.

Keywords: *Transformation · Profitability · Rice farming · Commercial farming · Livelihood · Bangladesh*

1. Introduction

Encompassing an expanse of 148,460 square kilometres, Bangladesh stands as a prominent agriculture-based developing nation on the global stage. Since attaining independence in 1971, agriculture has held its position as the cornerstone of the country's economy, contributing approximately 11.38 percent to the GDP (BBS, 2022). This sector plays a multifaceted role, serving as the primary source of employment, livelihood, and food security for most rural inhabitants and as a crucial supplier of raw materials to industries, contributing significantly to the nation's exports. Despite the prevailing trend towards industrialisation in the modern economy, agriculture remains the lifeblood of many agrarian economies, Bangladesh being a notable example (Bishwajit et al., 2014). Rural livelihoods have been predominantly shaped by agricultural activities for many years (T. Ahmed, 2015); a staggering 84 percent of the rural population in Bangladesh is directly or indirectly reliant on agriculture for their sustenance (Moyen Uddin, 2015). The significance of farming practices in Bangladesh extends beyond merely providing substantial employment opportunities. It plays a pivotal role in meeting the dietary requirements of the burgeoning population, emerging as a crucial factor in ensuring food security for the nation. In navigating the balance between modernisation and traditional practices, agriculture in Bangladesh remains a linchpin in addressing the evolving needs of its populace, both economically and nutritionally (M. Ahmed et al., 2021).

The transformation of land use emerges as a critical concern, particularly in tropical developing countries like Bangladesh (Ahammad et al., 2021a). Bangladesh's land use pattern is undergoing significant changes to meet the dynamic demands of society, exerting pressure on the natural environment and causing disharmony within the natural system (This shift is emblematic of agricultural modernisation, a transformative process transitioning from traditional practices, primarily rice farming, to a more diverse and commercially oriented approach involving fish, livestock, and poultry. This evolution integrates modern industry, advancements in science and technology, and sophisticated economic management methods, propelling agricultural productivity beyond traditional boundaries (Jannat et al., 2021). Over the years, Bangladesh has witnessed substantial land transformation fuelled by population and economic growth, infrastructure expansion (Islam & Hassan, 2011), and climate change (Rahman

& Manprasert, 2006). This metamorphosis is reflected in the transition from rice farming to commercial agriculture, driven by uncontrolled population increase and economic development. Small-scale farmers respond by making diverse land use decisions, shifting from crop fields to fisheries and converting rice farms into livestock and poultry farms in the short run to achieve food self-sufficiency. In this densely populated country, Bangladesh heavily relies on these evolving sectors to meet the escalating demand for food, protein, and livelihood opportunities (Ahmed & Waibel, 2019; Alamgir et al., 2023; Islam & Hoq, 2018). Globally, around 60% of land changes are directly associated with human activities, with the remaining attributed to indirect drivers like climate change from 1982 to 2016 (Song et al., 2018). Hence, proactive interventions, such as enhancing infrastructure access and mitigating the adverse effects of climate change, are imperative to ensure future yield growth. In Bangladesh, cropland use for commercial farming has expanded over time in response to market demand and a favourable profit growth rate. Simultaneously, rice production's unpredictability and low market prices have further propelled this transformation. Commercial practices in Bangladesh predominantly involve cultivating fish, livestock, and poultry. The conversion of rice farms into different commercial ventures, such as fish farms, poultry, and cattle farms, has reshaped the land use patterns of major cities. Bangladesh has emerged as a significant player in fish and animal production and export in South Asia, with vast water resources, including ponds, lakes, canals, rivers, estuaries, and coastal regions, fostering the growth of the aquaculture industry in recent decades (Gias, 2005; Shamsuzzaman et al., 2017). Livestock and aquaculture production are pivotal in sustaining the population's livelihoods. Consequently, these transformations have altered the physical landscape and led to significant changes in farmers' livelihood assets, encompassing human, social, financial, natural, and physical capital.

There is a scarcity of published literature that assesses changes in farmers' livelihood patterns resulting from transforming rice farms into commercial enterprises. Vongvisouk et al. (2014) explored the impact of shifting agriculture on rural livelihoods across six villages in northern and central Laos, noting an intensification of rice shifting cultivation with the introduction of cash crops. Ahammad et al. (2021b) studied land use changes and livelihood outcomes in rural Bangladesh, finding variations in household income among zones based on existing land uses. Hossain and Bayes (2009) provided insights into the rural economy of Bangladesh, covering agriculture, the non-farm sector, and the influence of agrarian structure on productivity, income distribution, and poverty.

Iiyama et al. (2008) examined livelihood activities in Kenya, identifying significant impacts of age, gender, education, proximity to training centres, and

credit on livelihood diversification. Rahman and Al-Amin (2016) investigated the transformation of rice fields into various ventures and highlighted the high production cost as a barrier to profitability. However, the comparative profitability of rice farming and commercial activities such as fish, cattle, and poultry farming remains underexplored in rural Bangladesh.

This research aims to fill the existing knowledge gaps by investigating how farmers' livelihoods evolve during the transition from high-yielding variety (HYV) rice farming to fish, livestock, and poultry farming. Additionally, the study seeks to compare the profitability of rice farms with different commercial ventures and identify significant constraints farmers face. The findings will contribute valuable insights to policymakers in formulating guidelines for rice and commercial farmers, ultimately enhancing overall livelihood conditions in Bangladesh.

2. Materials and Methods

2.1. Study Area

The research was conducted in the Mymensingh district, specifically in the Upazilas of Mymensingh Sadar and Muktagacha. These Upazilas were intentionally selected due to their significance as major commercial agricultural farming areas within the district, where notable transformations in land use have occurred over time. The motivation behind choosing these specific locations stems from the prevalent desire among farmers in the Mymensingh district to convert their traditional rice fields into fishponds and livestock farms, seeking to diversify their agricultural activities. The selection of Mymensingh Sadar and Muktagacha was strategic, driven by the observation that these Upazilas present a more dynamic and evolving scenario than other regions in Bangladesh. Researchers aimed to delve into these study sites, anticipating that the findings would yield valuable insights for future generations by capturing the nuances of changing agricultural landscapes. Moreover, the chosen locations were deemed ideal for scrutinising the shifts in livelihood patterns resulting from transforming rice fields into fish and livestock farming. The study sought to understand how such changes impact the local communities' economic activities and overall well-being. By focusing on these Upazilas, the research aimed to provide a nuanced understanding of the multifaceted implications of transitioning from traditional rice farming to more diversified agricultural practices, contributing essential knowledge for future agricultural planning and development.

2.2. Sample size

The primary focus of this study centred on individual farm households as the sampling unit. Three villages were carefully selected from each of the identified

Upazilas. In the selection process, commercial farms were chosen through a random sampling method, and similarly, rice farmers were randomly selected to ensure a representative and unbiased sample. The aim was to comprehensively understand both commercial and traditional rice farming contexts within each village. A total of 120 respondents were included in the study, 40 of whom were rice farmers and 80 commercial farmers.

2.3. Data collection and data management

The method employed for data collection was personal interviews, allowing for a detailed exploration of the dynamics within each household. In the context of this research, the household served as the primary unit of analysis, with a specific focus on the household head who assumed the role of the main informant. The decision to interview household heads was grounded in recognising that, in the Bangladeshi context, the household head plays a pivotal role as the primary decision-maker in farming and other family operations.

Qualitative and quantitative research methodologies were employed to collect primary data for this study. The primary sources of information were interviews with key informants and a questionnaire survey conducted among farm households. Initial data gathering involved engaging with respondents, followed by a comprehensive household survey. Participants were given a concise overview of the research objectives and data requirements.

To gather insightful information from the selected households, a deliberate and personalised approach was adopted, employing face-to-face interviews. This method involved using a meticulously designed questionnaire with closed-ended questions.

The finalised version of the refined questionnaire was subsequently deployed in the actual survey, aiming to comprehensively capture the diverse perspectives, thoughts, and challenges farmers face. The questionnaire's coverage spanned various essential topics, encompassing farmers' farm profiles, details regarding rice's high-yielding varieties (HYV), and specifics related to fish, livestock (cattle), and poultry farming. Furthermore, the questionnaire probed into the profound changes in farmers' livelihood patterns resulting from agricultural transformations, shedding light on their major challenges. By employing this extensive set of questions, the study aimed to capture a holistic view of the intricate dynamics shaping farmers' experiences in the context of agricultural transformation.

2.4. Data Analysis

After collecting data from the household survey was coded correctly, a master sheet was created in MS Excel. The data cleaning process was also done on the

MS Excel master sheet after entering all the data. Descriptive statistical methods like average, percentage, etc., were utilised to analyse the comparative profitability of rice, fish, livestock, and poultry farming. The MS-EXCEL software was used to exhibit the results of the descriptive analysis in tables. The Chi-square test was employed to assess the change in the livelihood pattern of respondent farmers through the transformation of agriculture.

2.4.1. Comparative Profitability Analysis of Rice and Diversified Commercial Farming

Collected data were presented in a tabular sheet. Analyses were done by classifying the tables according to the study's objectives. Simple correlations between dependent and independent variables were examined in tabular analysis. Farm business analytical procedures such as enterprise costing, gross margin and benefit-cost analysis were carried out to determine the firms' profitability. The following formulas are provided:

Gross Return (GR)

The average price during the harvesting season was multiplied by the entire volume of output produced by a firm to determine gross return.

The following equation was used to estimate the Gross Return:

Gross Return,

$$GR_i = \sum_{i=1}^{n} QiPi$$

Where,

GR_i= Gross return from the i^{th} product (Tk./ha);

Q_i= Quantity of the i^{th} product (Tk./ha);

P_i= Average price of the i^{th} product (Tk./kg); and

Computation of total cost (TC)

Total cost (TC) includes all variable and fixed cost items involved in the production process. The total cost was estimated as follows:

$$TC = \Sigma P_{xi} \times X_i \times A + TFC$$

Where,

TC=Total cost (Tk./ha);

P_{xi} = Per unit price (Tk./kg);

X_i=Quantity of input (kg/ha);

A= Area under production measured in hectare; and

TFC=Total fixed cost

Gross Margin (GM)

Gross margin is the difference between revenue and expenses. It is typically determined by the difference between the gross return and the total variable costs.

The following equation was used to determine the gross margin:

$$GM=GR-TVC$$

Where,

GM = Gross margin;

GR= Gross return; and

TVC=Total variable cost

Net Return

In the net return analysis, fixed factors, including cost and land rent, interest on operating capital, etc., were considered. The profitability analysis was computed by subtracting the gross return from all costs (both variable and fixed). To determine the net return of production, the following equation was used:

$$\pi = \sum_{i=1}^{n}(PyY) - \sum_{i=1}^{n} PxiXi - TFC$$

Where,

π = Net return (Tk./ha);

P_y = Per unit price of the product (Tk./ha);

Y = Quantity of the production per hectare (kg);

P_{xi} = Pert unit price of the i^{th} inputs (Tk.);

X_i = Quantity of the i^{th} input per hectare (kg);

TFC = Total fixed cost (Tk.) and

Benefit-Cost Ratio (Undiscounted)

A benefit-cost ratio (BCR) is an indicator used in the formal discipline of cost-benefit analysis, which attempts to summarise any research's overall value for money. The undiscounted benefit-cost ratio (BCR) is a relative measure used to compare benefits per unit of cost. BCR was estimated as a ratio of gross return and gross costs. The general rule of thumb is that the project is a good investment if the benefit is higher than the cost (BCR>1). The formula for calculating BCR (undiscounted) is specified below.

Benefit-cost ratio,

$$BCR = \frac{Gross\ benefit}{Gross\ cost}$$

2.4.2. Change in livelihood patterns

A chi-square test was employed to assess the change in the livelihood pattern of the respondent farmers through transforming rice farming into commercial agriculture.

A statistical technique called the chi-square test is used to compare actual outcomes with predictions. Analysing cross-classified category data is a prevalent practice in evaluation and research. Among the widely employed statistical analyses for investigating the relationship or disparity between categorical variables, Karl Pearson's chi-square tests and its variants stand out as frequently utilised methods (Franke et al., 2012). This test aims to establish whether a discrepancy between observed and expected data is the result of chance or a correlation between the variables you are researching. In order to better comprehend and analyse the relationship between our two category variables, a chi-square test is a great option. The chi-square test assesses the relationship between livelihood capital and the farming system.

Chi-Square Formula

The Chi-Square is denoted by χ^2. The chi-square formula is:

$$\chi^2 = \sum (O_i - E_i)^2/E_i$$

Where,

O_i = observed value (actual value)

E_i = expected value

3. Results and Discussion

3.1. Comparative Profitability Estimation

The sustainability of a business is reflected in the profit generated within a specific timeframe. Profit, defined as the gap between the monetary value of produced goods and the associated production resource costs, is contingent upon the revenue earned and operational expenses incurred by the business venture. The interplay of revenue and operating costs determines the net gain or loss the enterprise can experience.

3.1.1 Comparative Cost and Returns of Rice Farming

Table 1 provides a comparative breakdown of the costs associated with rice farming. For rice land preparation, the cost per hectare was Tk. 10,041, constituting 6.17 percent of the total cost, while the seed cost per hectare was Tk. 3,232, representing 1.99 percent of the total cost. In rice production, the per hectare costs of Urea, TSP, MoP, DAP, and Compost were Tk. 4,185, Tk. 4,332, Tk. 2,481, Tk. 2,265, and Tk. 825, respectively. These fertiliser costs comprised 2.57, 2.66, 1.52, 1.39, and 0.51 percent of the total production cost. The aggregate cost of fertilisers was Tk. 14,087, accounting for 8.7 percent of the total cost.

The labour costs for rice production included Tk. 29,620 for hired labour and Tk. 1,890 for family labour per hectare, with a total labour cost of Tk. 31,510,

making up 19.4 percent of the total cost. Pesticides and irrigation costs per hectare were Tk. 1,885 and Tk. 15,124, constituting 1.16 percent and 9.26 percent of the total cost, respectively. The interest on operating capital for rice production per hectare was Tk. 4,336, representing 2.67 percent of the total cost. These costs are variable expenses incurred in the day-to-day rice production process.

Notably, most farmers in the study area owned their land for rice cultivation. However, for those who rented land seasonally, the cost of land rental was considered a part of the land-use cost. For producers, land utilisation costs were considered fixed expenses, and the land-use cost for one hectare of field area was Tk. 63,646, making up 39.13 percent of the total cost. The comprehensive total cost, calculated by summing up all costs associated with the production process, amounted to Tk.162,642 per hectare.

Table 1: Per hectare total cost of Rice production

Items	Cost (Tk./Ha)	Percentage of total cost (%)
Variable cost		
Land preparation	10041	6.17
Seeds	3232	1.99
Fertiliser		
Chemical fertiliser		
Urea	4185	2.57
TSP	4332	2.66
MP	2481	1.52
DAP	2265	1.39
Organic fertilizer		
Compost	825	0.51
Insecticides	1885	1.16
Labor cost		
Family labor	1890	1.16
Hired labor	29620	18.21
Irrigation	15124	9.29
Transportation	8778	5.39
Interest on operation capital	4336	2.67
Others	2982	1.83
Total variable cost	**91974**	**56.55**

Fixed cost		
Land use cost	63646	39.13
Others	7021	4.32
Total fixed cost	**70667**	**43.44**
Total cost	**162642**	**100**

Comparative return of rice production is shown in Table 2. The overall rice farms income per hectare was Tk. 204830 and gross margin for rice production was Tk. 112856. Net return was calculated by deducting total cost from the gross return. Thus, per hectare net return for producing Rice was Tk. 42188. Table 2 shows that Benefit cost ratio (undiscounted) of rice production was estimated 1.25 implying that Tk. 1.25 would be earned by investing every Tk. 1.00 in rice production.

Table 2: Per hectare total return of rice production

Items	Return (Tk./Ha)
Return from main product, rice	186453
Return from by-product	18377
Gross Return	204830
Gross Margin	112856
Net Return	**42188**
Benefit cost ratio (Undiscounted)	**1.25**

3.1.2. Comparative Cost and Returns of diversified commercial farming

3.1.2.1. Comparative Cost and Returns of fish farming

As per Table 3, the total pre-stocking management cost per hectare amounted to Tk. 15,061, constituting a mere 0.40 percent of the overall cost. This cost includes poisoning, liming, and fertiliser costs. The per hectare stocking management cost, detailed in Table 6.8, stood at Tk. 393,753, making up 10.35 percent of the total cost. This category encompasses the cost of fingerlings and the expenses associated with fry transportation. The cost of fingerlings is contingent on their availability at the appropriate time.

Post-stocking management costs, outlined in Table 6.9, amounted to Tk. 2,801,778 per hectare, representing a significant 73.66 percent of the total fish production cost. This cost includes expenses related to feed, fertiliser, and netting. The use of supplementary or balanced feed emerges as a crucial factor for enhancing fish production, contributing to better growth and survival rates. The

data in Table 6.9 further indicates that the average fish feed cost per hectare was Tk. 2,650,535, accounting for approximately 69.68 percent of the total cost of fish production. Additionally, the per hectare average fertiliser and netting costs were Tk. 73,852 and Tk. 62,136, constituting 1.94 percent and 1.63 percent of the total production cost, respectively.

Examining labour costs per hectare for fish production, Table 3 reveals an average cost of labour Tk. 26,943, representing 0.7 percent of the total cost. The total variable cost of fish farming is Tk. 3,387,640 per hectare, while the total fixed cost is Tk. 416,123 per hectare, encompassing land use, machinery and tools, and pond preparation expenditures.

Table 3: Per hectare total cost of fish production

Items	Cost (Tk./Ha)	Percentage of total cost (%)
Variable cost		
Pre-stocking management cost:		
Poisoning	2597	0.07
Liming	3372	0.09
Fertiliser		
Organic fertiliser		
Cow dung	256	0.007
Chemical fertiliser		
Urea	2544	0.07
TSP	3003	0.08
MP	1964	0.05
DAP	1325	0.03
Total	**15061**	**0.40**
Stocking management cost		
Catla	24976	0.66
Silver carp	6592	0.17
Grass carp	5871	0.15
Mrigal	10374	0.27
Rui	28088	0.74
Raj-Puti	16124	0.42
Pangus	148644	3.91
Tilapia	28858	0.76

Items	Cost (Tk./Ha)	Percentage of total cost (%)
Others	115055	3.02
Fry transportation	9171	10.11
Total	**393753**	**0.24**
Post-stocking management cost		
Fish feed	2650535	69.68
Fertiliser	73852	1.94
Netting cost	153865	1.63
others	15255	0.4
Total	2893520	73.66
Labor cost	26943	0.7
Interest on operating capital	150105	3.64
Total Variable Cost	**3387640**	**89.06**
Total fixed cost		
Land use cost	362220	9.5
Machine and tools	10653	0.28
pond preparation	42005	1.1
Others	12452	0.03
Total fixed cost	**416123**	**10.94**
Total cost	**3803763**	**100**

Table 4 shows the overall profit from fish farming, with a total return of Tk. Tk. 6728920 and a gross margin of Tk. 3341280. The per-hectare net return for producing fish was Tk. 2925157, and the undiscounted BCR of fish production was estimated at 1.78, implying that Tk. 1.78 would be earned by investing every Tk. 1.00 in fish production.

Table 4: Per hectare total return of fish production

Items	Returns (Tk./Ha)
Catla	522007
Silver carp	298631
Grass carp	225831
Mrigal	375028
Pangus	1080234
Rui	704937

Raj-Puti	301391
Tilapia	816398
Others	2404463
Gross Return	6728920
Gross margin	3341280
Net Return	**2925157**
Benefit-cost ratio (Undiscounted)	**1.78**

3.1.2.2 Comparative cost and return of cattle farming

The comparative cost of cattle farming under the study area is presented in Table 5, which revealed that per hectare, the total variable cost was Tk. 1151729 per farm, which comprises 99.25 percent of the total cost. On the other hand, total fixed cost is meagre compared to variable cost, which was Tk.8732 per farm (0.75 percent of total cost). Variable costs of cattle production include expenditure on feed, labour, and veterinary care, as well as interest in operating capital. Fixed costs include housing and equipment costs for the maintenance of cattle.

Table 5: Per farm total cost of cattle farming

Items	Cost (Tk./Farm)	Percentage of total cost (%)
Variable Cost		
Purchase value of Animal	678238	58.45
Family Labor	1808	0.15
Hired Labor	6400	0.55
Paddy Straw(auti)	61707	5.32
Green grass	14717	1.27
Bran	271568	23.40
Salt	45048	3.88
Vitamin	2590	0.22
veterinary charge	3571	0.31
Electricity bill	7976	0.69
Transportation	2119	0.18
Interest on operating capital	54844	4.73
Other	1143	0.09
Total Variable Cost	**1151729**	**99.25**

Fixed cost		
Housing cost	4570	0.39
Equipment and tools	2580	0.22
Others	1582	0.14
Total Fixed Cost	**8732**	**0.75**
Total Cost	**1160461**	**100**

Table 6 shows that total return from cattle farming was Tk. Tk. 1550516, and the net return for producing cattle was Tk. 390055 per farm. According to Table 6, the undiscounted BCR of livestock production was estimated at 1.34, implying that Tk. 1.34 would be earned by investing every Tk. 1.00 in fish production.

Table 6: Per farm total return of cattle farming

Items	Return (Tk./farm)
Sell value of cattle	871667
Milk production	673474
By product	5375
Gross return	1550516
Gross margin	398787
Net return	390055
Benefit-cost ratio (BCR)	**1.34**

3.1.2.3 Comparative cost and returns of poultry farming

The total cost of poultry farming was determined by combining the total variable cost and the total fixed cost associated with poultry farming. The total variable cost encompasses expenses related to purchasing day-old chicks and feed and costs for labour, veterinary services, electricity, and interest on operating capital. Tables 7 and 8 provide detailed insights into the overall expenditure and net profit derived from poultry farming.

As outlined in Table 7, the total expenditure for poultry production amounted to Tk. 848,105 per farm. In contrast, the gross revenue from selling poultry products and by-products stood at Tk. 1,131,298 per farm, as depicted in Table 8. Consequently, the undiscounted Benefit-Cost Ratio (BCR) of poultry production was calculated at 1.33. This implies that for every Tk, 1.00 is invested in poultry production, which is an estimated Tk. 1.33 would be earned, emphasising the profitability and financial viability of poultry farming as a lucrative venture. The positive BCR suggests that poultry production is an economically sound investment, yielding returns that surpass the initial capital investment.

Table 7: Per farm average cost of poultry farming

Items	Cost (Tk./farm)	Percentage of total cost (%)
Variable cost		
Day-old-chicks	175166	20.96
Family labor	610	0.07
Hired labor	7784	0.93
Poultry feed	581958	69.65
Vitamin	3455	0.41
Veterinary charge	6888	0.82
Electricity bill	2455	0.29
Transportation	2334	0.28
Interest on operating capital	39086	4.68
Other	1063	0.13
Total variable cost	**820799**	**98.23**
Fixed Cost		
Land use cost	12500	1.47
Housing cost	7370	0.86
Equipment and tools	5584	0.66
Other	1852	0.22
Total fixed cost	**27306**	3.22
Total cost	**848105**	100

Table 8: Per farm total return of poultry farming

Items	Return (TK./farm)
Product	1108532
By product	22765
Gross Return	1131298
Gross Margin	310499
Net Return	283193
Benefit-cost ratio (Undiscounted)	**1.33**

Table 9 provides a conclusive insight into the profitability of diversified commercial farming compared to exclusive rice farming in the study areas. The net

returns per hectare were estimated at Tk. 29,25,157 for fish, livestock, and poultry farming, and Tk. 42,188 for rice farming. On a per-farm basis, the estimated net returns were Tk. 3,90,055 for fish farming, Tk. 2,83,193 for livestock farming, and Tk. 42,188 for rice farming.

Examining the undiscounted benefit-cost ratios (BCR), fish, livestock, and poultry farming exhibited ratios of 1.78, 1.34, and 1.33, respectively, surpassing the BCR of rice farming (1.25). This indicates that the returns generated from fish, livestock, and poultry farming outweigh the costs more significantly than those generated by rice farming. The higher BCR in commercial farming demonstrates its enhanced profitability.

Given the superior profitability of commercial farming, farmers in the study areas have shown increased interest in fish, livestock, and poultry farming alongside subsistence rice farming. This heightened interest is evidenced by the transformation of rice land into fish, livestock, and poultry farms, primarily driven by the favourable financial aspects of commercial farming. The findings suggest a strategic shift in farming practices as farmers seek to maximise their economic returns by diversifying into more profitable ventures.

Table 9: Comparative Profitability of Rice Farming and diversified Commercial farming (Fish, Livestock, Poultry)

Items	Rice Production	Fish Farming	Cattle Farming	Poultry Farming
	(Tk./Ha)	(Tk./Ha)	(Tk./farm)	(Tk./farm)
Total fixed cost	70667	416123	8732	27306
Total variable cost	91974	3387640	1151729	820799
Total cost	162642	3803763	1160461	848105
Product	186453	6728920	1545141	1108532
By product	18377	0	5375	22765
Gross Return	204830	6728920	1550516	1131298
Gross Margin	112856	3341280	398787	310499
Net Return	**42188**	**2925157**	**390055**	**283193**
Benefit-cost ratio (Undiscounted)	**1.25**	**1.78**	**1.34**	**1.33**

3.2 Change in livelihood patterns

The decision to shift land significantly enhanced farmers' livelihood assets, encompassing human, social, financial, natural, and physical capital (Islam et al., 2020). Changes in livelihood resources and strategies were notably influenced by

policy and institutional shifts, including alterations in forest and land management laws, agricultural policies, forest policies, national projects, and social culture. Consequently, villagers adopted diverse livelihood strategies based on their individual conditions, such as agricultural intensification, livelihood diversification, or migration (Lu et al., 2020).

In line with sustainable livelihoods theory, as outlined by (McLeod, 2001), the recognised assets include:

i. Natural (Environmental) capital: Involves natural resources like land, wildlife, water, environmental resources, and biodiversity.

ii. Physical capital: Encompasses basic infrastructure such as housing, along with the means and instruments of production, including water, energy, sanitation, transport, and communications.

iii. Human capital: Encompasses health, education, skills, and the capacity for work.

iv. Social capital: Encompasses social resources like group memberships, trustworthy relationships, access to broader institutions, and networks.

v. Financial capital: Encompasses financial resources available, such as regular remittances or pensions, savings, and access to credit supplies.

3.2.1 Human Capital

Human capital encompasses various factors such as knowledge, skills, attitudes, education, mental and physical health, ability to work, and training, collectively empowering individuals to pursue their livelihood strategies (Šlaus & Jacobs, 2011). The association between adopting commercial farming and the resulting changes in human capital was assessed using the chi-square test, as detailed in Table 10. The statistical significance of the chi-square test ($p < 0.05$) indicates a robust relationship between human capital and the shift in farming systems.

Crucial components of human capital include health and sanitation, and the table reveals that 96.2% of the selected commercial farmers reported an improvement in their health and sanitation through the transition from rice farming to commercial farming. Education, another vital asset of human capital, was categorised into four levels: 1) primary level (1 to 4 years of education), 2) secondary level (6-10 class), 3) higher secondary level (10-12 years), and 4) Degree (Bachelor and Masters) (Karim, 2006). Among commercial farmers, 81.3% noted an enhancement in the education level of family members through the transformation from rice farming to diversified commercial farming.

Moreover, 57.5% of respondents indicated that they underwent training following the shift from rice farming, contributing to a substantial improvement

(about 95%) in their technological knowledge about commercial farming. Additionally, 86.3% of commercial farmers experienced an increase in their ability to access information through this transformative process. These findings underscore the profound impact of commercial farming on various dimensions of human capital, ranging from health and education to technological knowledge and information accessibility.

Table 10: Changes in human capital

Components	Pearson Chi-Square	Asymptotic Significance (2-sided)	Improved		Unchanged	
			No.	(%)	No.	(%)
Health and sanitation	107.442	.000	77	96.2	3	3.8
Education	59.067	.000	65	81.3	15	18.8
Training	33.856	0.000	46	57.5	34	42.5
Efficiency/ Knowledge	103.636	0.000	76	95.0	4	5.0
Access to information	76.954	0.000	69	86.3	11	13.8

3.2.2 Social Capital

Social resources are shaped by relationships and networks within nuclear and extended families and among various communities and groups (Coleman, 1988). Informal social relations lay the foundation for informal safety nets, serving as crucial support mechanisms that individuals rely on to navigate challenges and emergencies in their pursuit of livelihood strategies (Kleih et al., 2003). Maintaining positive relationships with neighbours becomes imperative for survival during difficult situations, and these connections often result in financial benefits (M. Ahmed et al., 2021).

The adoption of commercial farming exhibited a positive correlation with the social capital of farmers, as indicated by a significance level of $P<.05$ (Table 11). Most farmers reported improvements in their social involvement (90%) and political engagement (61.3%) following their engagement in commercial farming. Additionally, approximately 91.3% of respondents affirmed an enhancement in their self-managerial capacity through the transition from rice farming to commercial farming. Moreover, 95% noted an increase in their self-prestige as a direct result of adopting commercial farming practices. These findings underscore the transformative impact of commercial farming on economic aspects and the social well-being and self-perception of the farmers involved.

Table 11: Changes in social capital

Components	Pearson Chi-Square	Asymptotic Significance (2-sided)	Increased		Unchanged	
			No.	(%)	No.	(%)
Social capital	90.00	0.000	72	90.0	8	10
Political involvement	41.408	0.000	49	61.3	31	38.8
Self-managerial capacity	93.191	0.000	73	91.3	7	8.8
Social prestige	103.636	0.000	76	95	4	5

3.2.3 Natural Capital

Natural capital refers to the quality and quantity of available natural resources, with a crucial emphasis on people's access to and control over these resources (Deswandi, 2017). This encompasses the inflows and services provided by natural resources, making them integral components of natural capital. The information regarding the sample farmers' cultivable land and pond area was considered in this context.

Table 12 reveals that only 26.3% of respondents experienced increased cultivable land through the transformation from rice farming to commercial farming. Conversely, about 71.3% of farmers observed an expansion in their pond area because of transitioning from rice farming to commercial farming. This notable increase in pond area can be attributed to the widespread adoption of fish farming among these farmers, surpassing other agricultural activities. The data underscores the impact of commercial farming transformations on natural capital, particularly in the expansion and utilisation of pond areas for fish farming.

Table 12: Changes in natural capital

Components	Pearson Chi-Square	Asymptotic Significance (2-sided)	Increased		Unchanged	
			No.	(%)	No.	(%)
Cultivable land	51.150	0.000	21	26.3	59	73.8
Pond area	54.286	0.000	57	71.3	23	28.7

3.2.4 Physical Capital

Physical capital encompasses essential infrastructure like transportation, housing, water, energy, communication facilities, and production equipment, enabling individuals to pursue their livelihoods (Rakodi, 2014). This category includes household furnishings, equipment, and various forms of physical infrastructure.

Table 13 underscores a noteworthy and positive relationship between the adoption of farming systems and the physical capital of the respondents. Among commercial farmers, approximately 82.5% reported improvements in their housing conditions, emphasising the tangible impact of adopting new farming practices on their living spaces. Furthermore, about 92.5% of farmers experienced an enhancement in the furniture within their homes, indicating a positive correlation between commercial farming and improvements in household assets. Additionally, around 65% of these farmers invested in computers and arranged cable networks, underscoring a proactive approach towards providing educational resources for their children. This highlights the broader positive impact that the adoption of commercial farming systems can have on the physical capital of households, contributing to improvements in living conditions and educational opportunities for the family.

Table 13: Changes in physical capital

Components	Pearson Chi-Square	Asymptotic Significance (2-sided)	Increased		Unchanged	
			No.	(%)	No.	(%)
Housing	69.209	0.000	66	82.5	14	17.5
Furniture	57.857	0.000	74	92.5	6	7.5
Cable network	44.348	0.000	51	63.7	29	36.3
Computer/ laptop	41.408	0.000	49	61.3	31	38.8
Freeze	82.656	0.000	91	88.8	9	11.2

3.2.5 Financial Capital

Individuals' financial resources, such as income, savings, credits, and remittances, constitute their financial capital, offering diverse livelihood options (Rakodi, 2014). This capital serves as a pivotal asset, facilitating the acquisition of other forms of capital, including natural capital (e.g., land), physical capital (e.g., fishing equipment), or human capital (e.g., education or training). Additionally, increased financial capital can enhance one's social capital, as a higher socioeconomic status often aligns with a stronger financial position (M. Ahmed et al., 2021).

As depicted in Table 14, adopting commercial farming practices, such as fish, livestock, and poultry farming, increased farmers' financial capital. Approximately 75% and 97.5% of respondents affirmed that they could retain more cash and increase their savings after transitioning from rice farming to commercial farming. This shift was attributed to the increased profitability of commercial farming compared to traditional rice farming.

Table 14: Changes in financial capital

Components	Pearson Chi-Square	Asymptotic Significance (2sided)	Increased		Unchanged	
			No	(%)	No	(%)
Cash in hand	60.000	0.000	40	75%	20	25%
Savings	111.429	0.000	78	97.5%	2	2.5%
Jewellery	36.000	0.000	45	56.3%	35	43.8%

The study indicates that various livelihood assets increased for commercial farmers when they transitioned from rice farming to commercial agriculture. With diversified commercial farming proving more profitable than sole reliance on rice cultivation, commercial farmers found an opportunity to enhance their livelihood patterns. By converting their cropland into fish, livestock, and poultry farming, these farmers strategically improved their financial prospects, contributing to an overall improvement in their livelihoods.

3.3 Problems faced by the respondent farmers of the study area

In Bangladesh, there is a constant need to boost the production of crops, fish, livestock, and poultry to meet the growing demand for food. However, these agricultural practices pose risks to the environment and present numerous challenges for farmers. These challenges include shortages of quality fertiliser, seeds, feed, and hired labour, financial constraints, a scarcity of good fingerlings and day-old chicks, and other financial issues. This article addresses the broad spectrum of problems and difficulties associated with farming in the examined regions. Furthermore, this chapter proposes potential solutions to mitigate and manage the challenges linked to rice farming and commercial farming.

3.3.1 Constraints faced by commercial farmers

Every agricultural venture encounters challenges, and fish, livestock, and poultry farming are no exceptions. A survey of sampled households identified the prevalent issues in commercial farming, which are presented in Table 15. The survey revealed that the escalating price of feed, driven by the current state of the global market, is a significant concern for farmers engaged in fish, cattle, and poultry farming. Most respondents (65%) perceive the high feed price as a major challenge in their farming businesses.

The importance of high-quality feed for successful commercial farming is acknowledged, as excessive use of low-quality feed leads to poor appetite, sluggish growth, high feed conversion ratios, and low survival rates. Approximately 66%

of respondents recognised the problem of using low-quality feed in farming. Other challenges highlighted in the survey include the high cost of fingerlings, encountered by 75% of commercial farmers, and the high price of day-old chicks, reported by 85% of respondents engaged in commercial farming. Additionally, 64% of respondents faced challenges at the outset of their farming journey due to a lack of capital, emphasising the critical role of sufficient capital for starting and investing in a new agricultural business. Water management problems in fish farming areas, resulting from the use of pesticides and fertilisers, were reported by 39% of respondents. On the other hand, 61% of respondents did not encounter such issues during their fish farming endeavours.

Table 15: Problems faced by commercial farmers

Problems	Yes (%)	No (%)
High Feed Price	65	35
Quality of Feed	66	34
Lack of good quality fingerlings	35	65
The high price of fingerlings	75	25
The high price of day-old chicks	85	15
Lack of Capital	64	36
Illness determination issue	45	55
Difficulty with water management	39	61

3.3.2 Problems Faced by the Rice Farmers

Table 16 outlines rice producers' prevalent challenges, with high input costs, insufficient capital, labour shortages, low rice prices, pest and disease issues, and a lack of quality seeds identified as the most frequent issues. The rising costs of necessary inputs, driven by global market competition, pose a significant burden on farmers who now have to acquire these inputs at a higher expense.

A substantial majority (75%) of respondents express concerns about the escalating input costs, considering it one of the primary challenges in rice cultivation. Additionally, around 50% of rice farmers faced initial challenges in crop farming due to a lack of capital, emphasising the need for sufficient financial resources to initiate business or procure necessary inputs.

The shortage of hired labour prolongs production time in crop farming, although roughly 60% of rice growers did not encounter significant difficulties in hiring workers for their fields. The remaining 40% reported occasional challenges in securing labour, causing delays in rice production.

Effective pest and disease management is crucial for sustainable production,

and approximately 55% of respondents claimed they could identify and address these issues before implementing measures. However, 45.8% of rice farmers expressed concerns about the unavailability of quality seeds, emphasising the importance of good-quality seeds for successful crop cultivation.

Table 16: Problems faced by the rice farmers

Problems	Yes (%)	No (%)
High input cost	75	25
Lack of capital	50	50
A labour shortage	40	60
Unfair price of rice	71.8	28.2
Pest and disease management	55	45
Lack of quality seeds	45.8	54.2

The elevated education level of commercial farmers contributes to their superior access to extension services and information compared to rice farmers. This heightened accessibility may explain their ability to resolve challenges more efficiently. Conversely, limited education and restricted access to information and extension services hinder rice farmers from effectively addressing issues and achieving the desired output levels.

4. Conclusion

The research aimed to evaluate the financial profitability of rice farming compared to diversified commercial farming, which includes crops (rice), fisheries, livestock (cattle), and poultry as part of a commercial venture. The implications of these farming practices on farmers' livelihood patterns were also examined. The study found that diversified commercial farming proved more profitable than sole reliance on rice farming in the studied areas, demonstrating the economic viability of transitioning to commercial agriculture.

The research highlighted that transforming rice farms into commercial ventures led to increased livelihood assets for farmers. Converting rice land into diversified farms, incorporating fishery, livestock, and poultry empowered commercial farmers to enhance their livelihood patterns. Notably, the study revealed that commercial farmers tended to have higher education levels than rice farmers. This educational advantage facilitated better access to extension services and information and a more profound understanding of overcoming constraints.

Based on the findings, the study recommends providing educational support, especially for the children of farmers, to elevate literacy levels. Additionally, there

is a suggestion for training programs aimed at adopting new technologies and improving farm management practices to enhance farmers' income levels. The relevant authorities, such as the Ministry of Fisheries and Livestock, are encouraged to organise workshops, seminars, conferences, and live demonstrations to impart knowledge on the latest production and marketing techniques to grassroots-level commercial farmers and entrepreneurs. Furthermore, the availability of financial support, such as collateral-free credit from formal and semi-formal institutions, is recommended to facilitate the financial well-being of commercial farmers.

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