Annals of Bangladesh Agriculture
Journal homepage: gau.edu.bd/aba

ORIGINAL ARTICLE

Economic viability and livelihood effect of floating vegetable farming: evidence from waterlogged areas of southern Bangladesh

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ARTICLE INFO.

Keywords:

FVF, economic viability, livelihood effect, waterlogged areas, Bangladesh.

Received : 2 November 2025
Revised : 12 May 2025
Accepted : 18 May 2026
Published : 10 June 2026

Citation:

Islam M. N., M. T. Parvin, D. C. Acharjee, A. Sarkar, K. R. A. Misha, S. Islam, Y. I. Ankon, M. M. Islam and M. Noorunnahar. 2026. Economic viability and livelihood effect of floating vegetable farming: evidence from waterlogged areas of southern Bangladesh. *Ann. Bangladesh Agric.* 30(1): 147-166

ABSTRACT

Climate change is a major concern for agricultural and rural development, leading to flooding and prolonged waterlogging in southern Bangladesh. To address this, Floating Vegetable Farming (FVF) has emerged as a unique, indigenous, and climate-resilient farming practice that enables farming in waterlogged conditions. This study aims to investigate the economic viability and livelihood effects of FVF and identify the determinants of profitability, so that it can serve as evidence whether this innovative practice can be adopted widely. Using a cross-sectional household survey approach, data were collected from 120 FVF farmers in Gopalgonj district using a structured questionnaire and a random sampling technique. Profitability was calculated using the Benefit-Cost Ratio (BCR), and the determinants of profitability were identified using the Multiple Linear Regression Model (MLRM). Additionally, Impact Index (II) was utilized to assess the livelihood impact of FVF. The results reveal that FVF was highly profitable for most vegetables, with BCRs exceeding 1.90. Among the vegetable enterprises, cauliflower was the most profitable, with a BCR of 3.17, and brinjal was the least profitable, with a BCR of 1.62. The functional analysis reveals that education , farming experience and land size significantly determined profitability in waterlogged farming conditions. The practice substantially improved livelihood, as evidenced by improved household income (II = 95.83%) and increased women's involvement in farming (II = 86.68%). The results reflect economic viability of FVF, and its high impact on livelihood improvement, as reflected by higher II scores in most of the livelihood indicators. To ensure the long-term viability and sustainability of FVF, this study suggests increasing training exposure and institutional credit, and developing a market for organically produced floating vegetables to scale up this practice in the country's waterlogged areas.

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https://doi.org/10.3329/aba.v30i1.85301
ISSN 1025-482X (Print)/2521-5477 (Online)

Introduction

Bangladesh is predominantly an agricultural country, and agriculture also plays a significant role in national development. It employs approximately 45 per cent of the overall workforce and generates approximately 11 per cent of the country's Gross Domestic Product (MoF, 2024). It plays a vital role in the food security of millions of people and in rural livelihoods. Vegetable production in Bangladesh has almost doubled over the last 10 years. Despite this, however, the national production has not been able to meet the estimated annual demand of 13.25 MT due to the persistent supply gap (Rahman *et al.*, 2020; Statista, 2025).

Agriculture is highly vulnerable to climate variability and extreme weather events, although it is important to the nation's economy. The topography of Bangladesh is low-lying and has a large river network, which is more likely to experience flooding and protracted waterlogging (Mirza, 2003). On average, 20-25 percent of the national land area is inundated by floods annually, and at times of extreme floods, the extent of land coverage is significantly greater (BWDB, 2008; BWDB, 2012). Waterlogging is reported to affect around 45 million hectares of land in South Asia. It also affects conventional farming practices, productivity, and rural livelihoods (Hofman and Durnford, 1999; Hillel, 2003).

To address these environmental issues, Floating Vegetable Farming (FVF), also known as Dhap or Baira, has emerged as a significant indigenous, low-cost method for climate change adaptation (Jahan and Khanam, 2020). The innovative hydroponic system is based on the use of locally available aquatic biomass (Practical Action, 2021) to create floating beds that enable plants to be grown on water surfaces in flooded and waterlogged fields. The practice of FVF is widespread across the wetland ecosystem of southern Bangladesh, particularly in Gopalganj, Pirojpur, and Barishal districts. The system transforms the flooded land into floating beds to be used for cultivating various crops and vegetables, and provide income opportunities to landless and marginalized farmers (Bala *et al.*, 2020; Mohsin and Ferdousi, 2019). In addition to economic advantages, FVF also fosters the improved and sustainable use of the environment and social integration, including female participation in agricultural activities.

The increased popularity of FVF has drawn the attention of numerous scholars both in Bangladesh and abroad. The literature available mostly reflects its socio-economic benefits, and it is often assumed that FVF is a sustainable, higher-revenue income source than traditional farming in waterlogged conditions (Bala *et al.*, 2020; Rana, 2018). The practice is mostly adopted by smallholder and marginalized farmers in southern Bangladesh and reported to have improved household income, food security, and increased women's participation in agricultural production (Sarker *et al.*, 2025; Chowdhury and Moore, 2017; Dhali *et al.*, 2014; Mohsin and Ferdousi, 2019; Hossain, 2020). Furthermore, the low-cost, organic, and replicable nature of FVF led to its global acceptance as a transferable adaptation solution in other low-lying, flood-prone regions, including the Mekong Delta (Irfanullah, 2014;

Irfanullah, 2018). Decomposition of floating beds to organic substances, which can be utilized as bio-fertilizer in the next stage, also promotes environmental sustainability (Jahan and Khanam, 2020).

Despite the growing body of literature discussed above, there are still critical gaps to be addressed. Empirical research on FVF in Bangladesh has been mainly descriptive and case study-based that documented the profitability and socioeconomic benefits of floating agriculture (Sarker *et al.*, 2025; Bala *et al.*, 2020; Mohsin and Ferdousi, 2019; Chowdhury and Moore, 2017). The studies discussed above provided useful information about how such a system works. However, they did not provide any comparative analysis across crop types and did not systematically analyse the cost structure under different production conditions. Similarly, existing research on livelihood performance was largely descriptive and offered limited quantitative evidence on the impact of FVF in improving farmers' livelihood. Consequently, there is still no empirical research that incorporates both profitability and quantifiable welfare-related impacts. Unlike previous studies, this study this study aims to fill these gaps by simultaneously evaluating crop-wise profitability, livelihood impacts and determinants of profitability using econometric analysis. Therefore, the objective of this study are: i) To evaluate the cost–return structure and relative profitability of different crops cultivated under FVF systems; and ii) To determine the effects of the FVF adoption on the livelihood of farmers, especially in regards to income and livelihood stability. Through these objectives, this study aims to contribute to the existing body of knowledge by offering a more systematic and empirically grounded perspective on the economic and social aspects of FVF in Bangladesh.

Methodology of the study

Selection of the study area

The study was conducted in the Gopalganj district of Bangladesh, where FVF is widely practiced due to its low-lying, waterlogged nature. Out of five upazilas under Gopalgonj district, two upazilas, namely Kotalipara and Tungipara, were purposively selected due to their long history of FVF, availability of a significant number of respondents, easy accessibility, and enhanced institutional support from the local agricultural stations of the Department of Agricultural Extension (DAE) and Bangladesh Agricultural Research Institute (BARI) (Physi, 2024). These upazilas are recognized as important hubs of FVF, making them suitable for this study.

Sampling technique

This study is based on the quantitative research design intended to examine the economic viability and livelihood effects of FVF in southern Bangladesh. Using a cross-sectional household survey, data were collected through face-to-face interviews with the respondents, using simple random sampling. The data included authentic, experience-based, and non-fabricated information on production costs, income, and changes in livelihoods due to FVF adoption. The fieldwork was carried out during January and February 2025.

Sampling frame and sample size

The sampling frame comprised all households engaged in FVF in the selected upazilas, identified from the records of the DAE and BARI. According to DAE, over 2,000 farmers are involved in FVF in Gopalganj district. From this population, a sample of 120 farmers, with 60 farmers chosen from each upazila for proportional representation, was selected using simple random sampling to minimize selection bias. According to Cochran (1977) and Gujarati and Porter (2020), a standard sample size for statistical and regression-based analysis and interpretation of coefficients must include more than 100 observations. From that pursuit, the selection of 120 samples seems adequate and appropriate for this study.

Analytical technique

The analyses were performed in three different steps. First, the BCR analysis was performed to assess FVF's profitability. Second, the functional analysis using MLRM was used to identify factors influencing Profitability. Finally, II was used to assess the livelihood improvements resulting from farmers' involvement in FVF. All three analyses were intended to be connected to livelihood improvement, as they explain it from three complementary perspectives: economic performance, perceived changes in welfare, and causal drivers. The BCR analysis assesses the economic viability of FVF by comparing the activity's returns with the costs incurred. The higher the BCR, the greater the profitability, which increases household income and financial capacity. Complementing this analysis is the II, which captures the multidimensional changes in farmers' well-being, including income, asset ownership, education, and access to services Furthermore, the MLRM indicates the socioeconomic and farm-level determinants of profitability.

The regression results thus indirectly explain the determinants of livelihood outcomes, as profitability is an important route to improving livelihoods. These methods together provide a comprehensive insight into how and why FVF improves livelihoods.

Profitability analysis

The financial viability of FVF for different crops was determined using the Gross Return (GR) and the BCR. Gross return (GR) and BCR were calculated using the following formula:

$$Gross\ Return\ (GR) = \sum Q_m P_m + \sum Q_b P_b$$

Where GR = Gross return from FVF, Q_m = amount of the produce, P_m = per unit price of vegetable (BDT[1] /kg), Q_b = amount of by-product, P_b = per unit price of by-product.

The value of BCR represents the return on investment of a single unit of money.

$$Benefit - Cost\ Ratio\ (BCR) = \frac{Gross\ Return}{Total\ Cost}$$

Functional analysis regarding the factors affecting the profitability of FVF

To determine the factors influencing FVF's profitability, a Multiple Linear Regression

1 BDT = Bangladeshi Taka. The current exchange rate: 1 USD = ~ 122 BDT as of 17 October, 2025

Model (MLRM) was used. The basic structural equation of the model has been adopted from Gujarati and Porter (2020) as follows:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots\ldots\ldots\ldots\ldots + \beta_n X_{ni} + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

- = Benefit-Cost Ratio (BCR) of FVF for the *i-th farmer*
- = Constant or intercept
- = Coefficients of the explanatory variables
- n-th explanatory variables for the i-th farmer, such as age, education, experience, household income, total farm size, land size under FVF, and training exposure of the respondents
- = Error term

The explanatory variables used in this study included age, education, experience, household income, total farm size, land size under FVF, and respondents' training exposure (Table 1). They were defined as follows:

Considering the dependent and independent variables explained above, the final structural equation to be estimated was as follows:

$$\begin{aligned} Profitability\ (BCR) &= \alpha + \beta_1\, Age + \beta_2\, Education + \beta_3\, Experience + \beta_4\, Income \\ &+ \beta_5\, Total\ farm\ size + \beta_6\, FVF\ land\ size + \beta_7\, Training + ui (2) \end{aligned}$$

Effect of FVF on the livelihood

The impact of FVF on farmers' livelihoods was measured using 15 parameters, based on Angelsen *et al.* (2011) and Liswanti *et al.* (2012), including income, production, savings, education, women's participation, asset ownership, and service access. Respondents were asked to rate changes in various parameters after the adoption of

Table 1. Variable description

Variable	Definition	Unit
Profitability (BCR)	Benefit-Cost Ratio of FVF	Ratio
Age	Age of respondent	Years
Education	Years of schooling	Years
Experience	Experience in FVF	Years
Income	Annual household income	BDT/Year
Farm size	Total landholding	Hectares
FVF land size	Land under FVF	Hectares
Training	Training exposure (1 = yes, 0 = no)	Dummy

floating vegetable farming. The parameters received specific values based on the observed changes: 1 indicated improvement or increased access, -1 indicated decreased or decreased access, and 0 indicated no change (i.e., the parameter did not change). This method of scoring aligns with standard livelihood assessment methods (Angelsen *et al.*, 2011). This scoring method is also widely used in livelihood studies to show directional change, but it is difficult to measure the extent of that change. The equal weighting assumes that each dimension contributes equally to overall livelihood outcomes, consistent with similar composite index approaches in the rural development literature.

The maximum score for each parameter was 120, indicating the maximum positive effect on all respondents, meaning the parameter was significantly positively affected by floating vegetable farming. Conversely, one of the parameters could have a minimum mark of -120, the largest negative impact on all households. Therefore, the impact score for each parameter was +/-120, representing the extent of the change.

$$Impact\ Index = \frac{Observed\ score\ of\ the\ each\ parameter\ (-120\ to\ 120)}{Highest\ Possible\ Score(120)} \times 100$$

The internal consistency and reliability of the livelihood II were assessed by Lee Cronbach's alpha coefficient (1951). The Cronbach's alpha coefficient for the 15 indicators was tested in SPSS, yielding an alpha value of 0.81. The Cronbach's alpha value of above 0.70 is generally acceptable, while the value of above 0.80 indicates good reliability (Nunnally, 1978). Thus, the selected indicators were sufficiently consistent for constructing a composite livelihood impact index.

Data Processing and Analysis

The data were entered into Microsoft Excel and SPSS for processing and analysis. The descriptive statistics were produced in Excel; the functional and regression analyses were performed using SPSS (version 20).

Results and discussion

Socio-demographic profile of the respondents

Though examining the socio-demographic profile is not a direct objective of this study, it has been analysed as it is linked to the economic and livelihood findings. Such an analysis helps to interpret the results in light of practical human and social aspects that go beyond profit figures.

The socioeconomic profile of the respondents is presented in Table 2. The mean age of the respondents was about 39 years, and the highest percentage (39.7%) was for the young age group (18-30 years). It implies that this innovative farming practice is more popular among the younger farmers and is practiced mostly by male respondents (66.9%), which represents the typical labour economy of agriculture in Bangladesh. Although the average family size was about 6, the highest proportion of respondents (39%) belonged to a medium-sized family. The level of education was relatively moderate in terms of the years of schooling (8 years), with secondary education (6-10 years) being the most common (33.9%), followed by high school education (11-12 years), accounting for about 33.1%.

The average total landholding size was approximately 0.71 hectares, and most (about 79.17%) of them were smallholders (0.2-1 ha). There were no large-scale farmers among the sampled respondents during 2025. Of the total land area, FVF covered about 48 percent, and the majority of the land was under single ownership (72.74%). The average farming experience was close to 10 years, with the majority (83.33%) having limited to moderate experience (less than 12 years).

The average annual income of the FF was about BDT 216,776, while more than 73% were in the medium-income group (BDT 122,368–321,166). The main occupation of 69.67% of participants was agriculture, and the FVF accounted for nearly 59% of total household income, underscoring its economic contribution. It is important to note that three-fourths of the farming population had attended training organized by various research organizations, including Bangabandhu Academy of Poverty Alleviation and Rural Development (BAPARD), DAE, BARI, and Bangladesh Fisheries Research Institute (BFRI). All these findings imply that small farmers were mostly practicing FVF, mostly young and moderately educated, and received some institutional support and technical assistance from various public organizations to sustain their livelihoods in the waterlogged regions of southern Bangladesh.

Table 2. Socio-demographic profile of FV farmers in the study areas

Categories of socio-demographic variables	Percentage of respondents
Age of the respondents (years)	
Young (18-30)	39.7%
Middle-aged (31-50)	35.5%
Old (above 50)	24.8%
Mean age	39
Gender distribution of the respondents	
Male	66.9%
Female	33.1%
Family size (number)	
Small (up to 4)	36%
Medium (5-7)	39%
Large (>7)	25%
Mean family size	6

Categories of socio-demographic variables	Percentage of respondents
B. Educational attainment (years of schooling)	
Illiterate (0)	0.9%
Primary education (1 to 5)	28.1%
Secondary education (6 to 10)	33.9%
Higher secondary education (11-12)	33.1%
Higher Studies (>12%)	4%
Mean level of education	8
Farm size (hectare) of the household	
Landless (<0.02 hectare)	9.17%
Small (0.2 to 1 hectare)	79.17%
Medium (1 to 3 hectares)	11.67%
Mean farm size (hectare)	0.71
Land area under FVF (% of total farm size)	48.33%
Land ownership pattern	
Single ownership	72.74%
Partnership	4.14%
Others/leased	23.62%
FVF experience (years)	
Low (up to 12)	83.33%
Medium (13-23)	12.50%
High (above 23)	4.17%
Mean experience	9.63
Annual income (BDT) of the household	
Low (<BDT 122368)	11.7%
Medium (BDT 122368 to Tk. 321166)	73.3%
High (>BDT 321166)	15.0%
Mean income	216776
Occupational profile	
Agriculture	69.67%
Business	10.66%
Driver	4.92%
Housewife	7.38%
Service	3.28%
Livestock	1.64%
Fisheries	1.64%
Others	0.82%

Categories of socio-demographic variables	Percentage of respondents
Income Source Contribution (%)	
FVF	58.91%
Other agricultural occupation	39.24%
Other non-agricultural occupation	18.15%
Training Exposer	
Yes	75.00%
No	25.00%
Received specialized FVF training (% of total respondents having training)	49.23%
Average training duration (days)	5
Training providers	BAPARD, DAE, Local Agriculture Offices of BARI, and BFRI
Total sample (N)	120

Profitability of FVF

The economic viability of FVF was calculated through BCR, and the results are presented in Table 3. The table reflects that the majority of the vegetables cultivated on floating beds were highly profitable, with an average BCR of 1.90. Among the vegetable enterprises, cauliflower was the most profitable, with a BCR of 3.17, followed by dhundol/luffa (2.23) and tomato (2.18). The higher relative profitability of cauliflower was due to its low production cost relative to market value, its shorter growing season, and high seasonal demand. A similar finding was reported by Bala *et al.* (2020) and Mohsin and Ferdousi (2019), who noted that FVF enables the efficient use of unproductive, waterlogged land while reducing land preparation costs.

On the contrary, brinjal was the least profitable vegetable with a BCR of 1.62. The low profitability might be due to increased maintenance costs and pest susceptibility. Studies by Islam *et al.* (2019) and Yang *et al.* (2022) also reported that pest management costs and fluctuations in market prices in climate-sensitive production systems significantly influence the profitability of vegetable enterprises. In addition, the net returns from vegetables with lower BCRs are lower due to higher labour and input intensities.

The overall profitability findings support that FVF is a financially viable adaptation strategy in waterlogged ecosystems by converting submerged land into productive agricultural space. This finding corroborates the findings of Chowdhury and Moore (2017) and Sarker *et al.* (2025)

Table 3. Financial metrics and BCR of FVF in the study areas

FV enterprises	Production (Kilogram/ hectare)	Gross return (BDT/ hectare)	Production cost (BDT/ hectare)	Profit (BDT/ hectare)	BCR
Red Amaranth	186254	9881215	4869336	5011879	2.02
Taro	64156.8	3488582	1828846	1659735	1.90
Bottle gourd	234683	11735800	5550977	6184823	2.11
Wax gourd	126714	2556275	1324495	1231780	1.93
Pumpkin	54057	3264705	1569101	1695604	2.09
Brinjal	17515	1262446	776866	485580	1.62
Snake gourd	2667	207619	102857	104762	2.01
Tomato	29175	1707667	780500	927167	2.18
Bitter melon	12100	936333	488011	448322	1.91
Okra	69289	4906398	2317308	2589090	2.11
Malabar spinach	29817	1795311	895263	900048	2.00
Cucumber	11042	617067	300288	316779	2.05
Cauliflower	6926	193503	60919	132584	3.17
Broccoli	2143	120952	57619	63333	2.09
Kohlrabi	6407	113337	54446	58891	2.08
Dhundol/Luffa	19626	1039416	464745	574671	2.23
Total Sample(N)	120				

Again, Figure 1 shows a heat map ranking vegetables by BCR values. The colour gradient (red to green) denotes profitability. Green indicates high BCR values, red indicates low BCR values. The diagram provides a clear visualization of the same scenario discussed earlier. In sum, it shows that most vegetables were profitable. Cauliflower was the most profitable vegetable, followed by dhundol/ luffa, tomato, bottle gourd, and orka. However, the lowest returns were obtained from brinjal, taro, and bitter melon. Vegetables with low returns may require better management practices and pricing strategies, whereas vegetables with high BCRs indicate that such investments are profitable and scalable.

Factors affecting the profitability of FVF

The functional analysis using MLRM (Table 4) revealed that three of the seven explanatory variables positively and significantly affected profitability while only one variable afftected

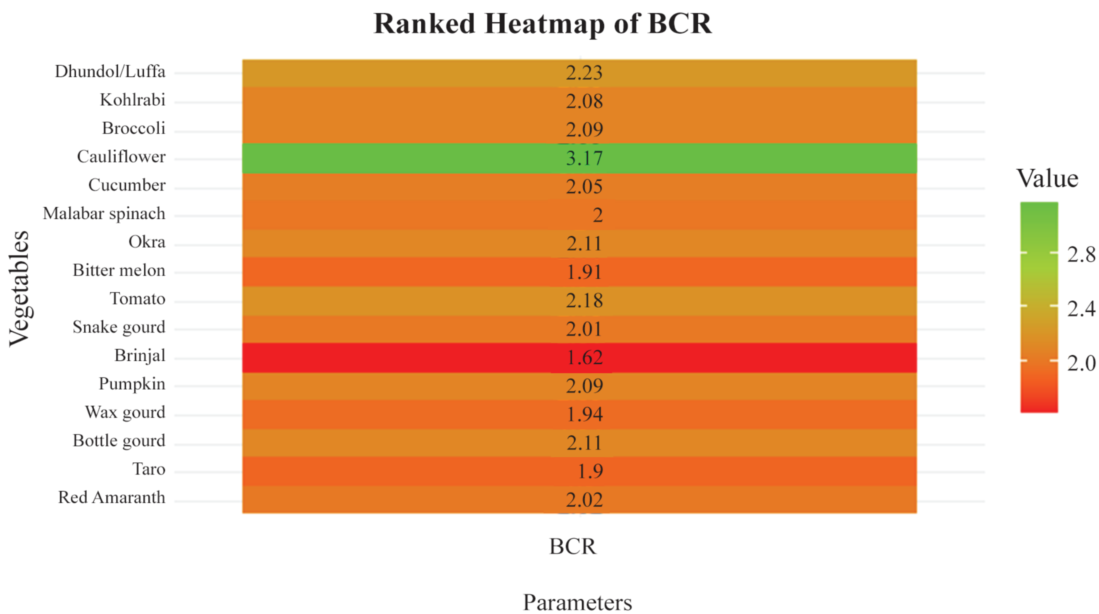

Fig. 1. Heat map of the vegetables according to their Benefit-Cost Ratio

the profitability negatively. Among them, land size (= 0.310*, p* = 0.012) was most influential, followed by farming experience (= 0.279, *p* = 0.000) and level of education (= 0.181, *p* = 0.050). The impact of land size is quite obvious: increased production volume, proxied by larger land size, is analogous to profitability. This finding is in line with Bala *et al.* (2020), who also reported that larger farm size is correlated with better commercialization opportunities and more efficient resource utilization, thereby generating higher returns. The positive effect of experience supports the relevance of practical knowledge in learning the advanced farming system. They are likely to be more familiar with preparing floating beds, selecting crops, pest control, and seasonal water dynamics. This result is consistent with Sakib and Afrad (2014), who reported that farming experience positively affects the successful adoption of innovative agricultural technologies in Bangladesh.

On the contrary, the coefficient of age was negative and marginally significant at 10% level, implying that profitability tended to decline as farmers' age increased. This result further indicates that the younger farmers may enjoy relatively higher profit due to their higher physical capacity, willingness to adopt improved production technologies and stronger managerial adaptability in the FVF.

Among the insignificant variables, education underscores the necessity of formalized information on this specialized farming system. Farmers with higher levels of schooling can adopt improved production techniques, manage floating beds efficiently, and access market information. Similar relationships between education and farm profitability were reported by Sarker *et al.* (2025) and Yasmin *et al.* (2013), who found that education increases farmers' adaptive capacity and technology adoption behaviour. The adjusted R-Squared (65.36%) and the high F-value (39.66) indicate the model's strong explanatory power for FVF profitability. Overall, this finding is supported by Sarker *et al.* (2025), who found that socioeconomic factors such as education, training, and prior knowledge are crucial for higher farm income and profitability under climate-sensitive conditions.

Post estimation diagnostics *of MLRM*

To ensure the reliability and validity of the estimated regression model examining factors affecting the profitability of FVF in Gopalganj district, several post-estimation tests were conducted, including tests for autocorrelation, multicollinearity, heteroskedasticity, and goodness of fit. These diagnostic checks help verify that the classical linear regression assumptions are met, ensuring unbiased and efficient estimators (Gujarati & Porter, 2008; Wooldridge, 2019).

Autocorrelation

Autocorrelation occurs when the residuals of a regression model are correlated across observations, leading to biased standard errors and test statistics. Although not tested, the possibility of serial correlation was low, as the current study is based on cross-sectional data from 120 independent farmers. Due to the independent nature of the dataset and the simple model specification following the Classical Linear Regression Model, assuming the disturbance term is independent

Table 4. Factors affecting the profitability of FVF in the study area

Variables	Values		
	Standardized Coefficients	t- value	p-value
(Constant)	–	10.182	0.000
Age	-0.198*	-1.774	0.079
Education	0.181**	1.847	0.050
Experience	0.279***	2.617	0.000
Income	0.165	1.468	0.145
Total land size	0.310***	2.558	0.012
FVF Area	0.143	1.291	0.199
Training	0.133	1.439	0.153
R-Square	71.23		
Adj. R-Square	65.36		
F-value	39.66***		

Note: ***p ≤ 0.01, **p ≤ 0.05 and *p ≤ 0.10

and identically distributed, the issue of autocorrelation was unlikely to arise in this study.

Multicollinearity

Multicollinearity is characterized by high correlation among the independent variables, which can overestimate standard errors and yield unstable coefficient estimates. Multicollinearity is usually identified with a test in SPSS that provided Variance Inflation Factor (VIF) value. The rule of thumb is that if the VIF is below 5, autocorrelation can be neglected and the model is acceptable (Kutner *et al.*, 2004). Luckily, the mean VIF was 1.83, with individual VIF of 1.62, 1.85, 1.78, 1.94, 2.13, 1.69, and 1.73, respectively. These values indicate that there were no multicollinearity problems in the model.

Heteroskedasticity

Heteroskedasticity arises when the variance of the residuals differs across observations, which can lead to inefficient estimates and invalid hypothesis tests. This problem is usually identified using the Breusch–Pagan or White test (Breusch and Pagan, 1979; White, 1980). This test provided a Breusch–Pagan test statistic of 1.82 with a p-value of 0.17, which is not significant at the 0.05 level. It indicates that the model is likely to meet the assumption of homoscedasticity.

Goodness of fit

The overall fit of the model, as indicated by the statistical significance of R2 (71.23) and adjusted R2 (65.36), suggests high explanatory power of the variables used in the model. The statistical significance of the F-value (2.90, $p<0.01$) confirms that the chosen variables explain about two-thirds of the variation in the profitability level of floating farmers, indicating the overall goodness of fit for this analysis (Gujarati and Porter, 2008).

All the test results suggest that the functional analysis conducted using MLRM is statistically appropriate, strong, and free of econometric violations.

Impact of FVF on farmers' livelihood

The livelihood impact assessment (Table 5) showed that FVF is not only a climate-resilient farming practice but also has the potential to transform the livelihood of rural communities. Based on the II, the most significant factor of livelihood improvement was income, followed by production (93.33%) and savings (89.17%). The substantial increase in income and savings indicates that FVF is a relatively reliable source of income during extended periods of waterlogging, when regular crop cultivation becomes difficult. This finding is supported by Dhali *et al.* (2014) and Sarker *et al.* (2025), who noted that FVF significantly promotes farmers' financial stability and agricultural output.

Another important livelihood effect of FVF is observed in women's participation in IGAs (86.67), which aligns with Mohsin and Ferdousi (2019). FVF is labor-intensive but homestead-oriented, allowing women to participate in activities such as seedbed preparation, bed management, harvesting, and marketing. Chowdhury and Moore also made similar observations, arguing that floating agriculture contributes to social inclusion and gender empowerment in rural Bangladesh.

Additionally, factors such as access to credit (71.67) and education (70.83) also showed a strong positive association, indicating that FVF not only improves the economy but also social and community welfare. However, the relatively negligible improvement in long-term assets, such as land and pond ownership, shows that, even though FVF has a positive, immediate, and consumption-oriented impact on livelihood improvement, it might not be able to generate sufficient capital accumulation to support major asset investment in the long run.

For a clear understanding of the livelihood effect of FVF, a radar diagram is drawn in Figure 2. It depicts the overall effects of FVF on various economic and social aspects of livelihood. The shaded area in Figure 2 shows the strongest positive influences of FVF on production, income, savings, and women's involvement in various IGAs. It also highlights the moderate effects of education, training, and access to credit, whereas factors such as asset ownership (land, furniture, ponds) had negligible effects.

In contrast, factors such as asset ownership (land, furniture, ponds) had negligible effects. This diagram is quite similar to conventional livelihood analysis frameworks, including the Sustainable Livelihood Framework (SLF) developed by the Department for International Development (DFID),

Table 5. Impact of FVF on farmers' socioeconomic and livelihood factors

Livelihood factors	Impact score		Impact index (%)	Rank
	Observed	Absolute		
Improved production	112	120	93.33	2nd
Land ownership	24	120	20.00	13th
Pond ownership	5	120	4.16	15th
Improved income	115	120	95.83	1st
Improved savings	107	120	89.17	3rd
Access to institutional credit	86	120	71.67	6th
Access to training	74	120	61.67	8th
Access to educational facilities	85	120	70.83	7th
Access to medical care	66	120	55.00	10th
Involvement in social groups	100	120	83.33	5th
Women's involvement in income-generating activities (IGAs)	104	120	86.67	4th
Procurement of furniture	18	120	15.00	14th
Procurement of agricultural equipment	41	120	34.17	12th
Mobile ownership	57	120	47.50	11th
Access to hygienic sanitary toilet	66	120	55.00	9th

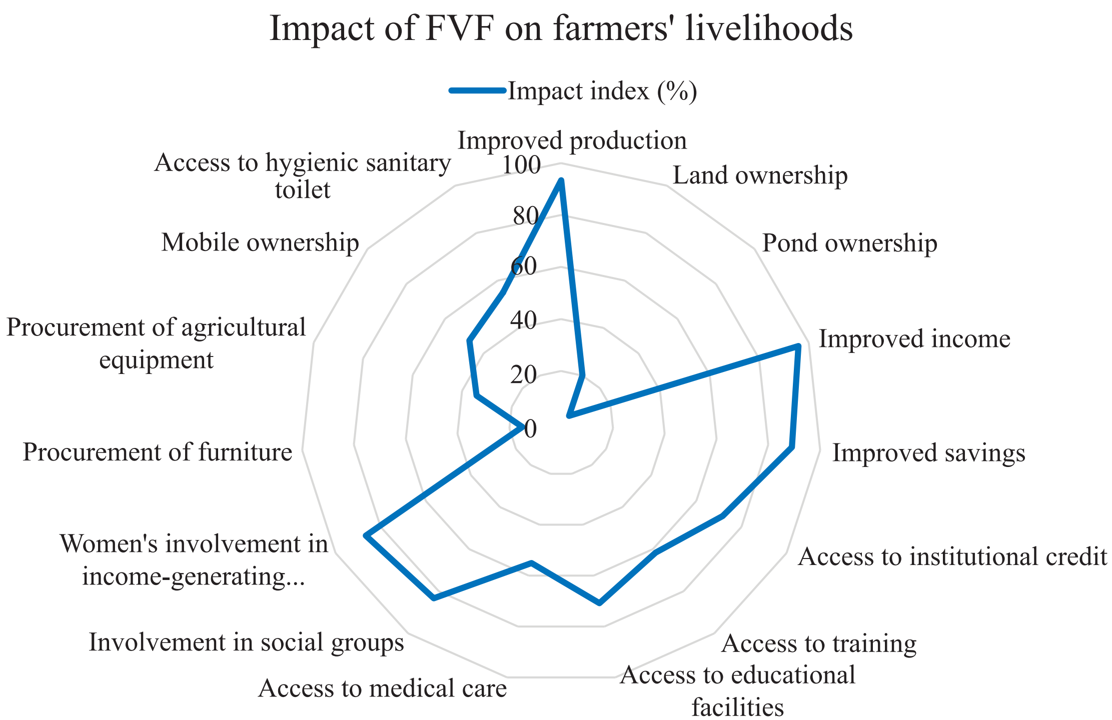

Fig. 2. A visual representation of the impact of FVF on farmers' livelihoods

United Kingdom, which evaluates various livelihood capitals (financial, social, human, physical, and natural). Therefore, the use of this diagram enabled this study to capture the multidimensional nature of livelihood as reflected by income, education, social participation, assets, and other welfare indicators.

Conclusion and recommendations

This paper has assessed the economic feasibility and livelihood effects of FVF in the waterlogged regions of southern Bangladesh using profitability, regression analysis, and a livelihood impact index. The results demonstrate the economic viability of FVF for a range of vegetable enterprises. The BCR for all crops is greater than 1, with an average of 1.90. Profitability of different crops varies among the vegetable enterprises, while cauliflower, luffa, and tomato show comparatively higher returns, indicating that these vegetables can be optimized individually.

The regression findings also indicate that education, farming experience, and total land size are important determinants of profitability, thereby indicating the importance of human capital and resource endowment in enhancing farm performance under floating cultivation systems.

The livelihood assessment shows a positive trend across all indicators. However, income (95.83%), production (93.33%), savings (89.17%), and women's participation in income-generating activities (86.67%) are the indicators with the greatest positive changes. The comparatively small changes to asset ownership suggest that FVF is a factor in improving short- to medium-term welfare but has a limited impact on long-term asset accumulation.

Based on these findings, several specific policy implications can be drawn. First, because education and experience significantly influence profitability, expanding access to specialized, continuous training programs can enhance farmers' technical efficiency and decision-making capacity. Second, given the positive but moderate increase in access to institutional credit (71.67%), the reinforcement of credit delivery institutions specific to smallholders can be used to encourage investment in inputs and the growth of FVF activities. Third, the profitability differences among crops indicate that market-based production planning and extension services are necessary so that farmers can focus on crops with higher returns. Lastly, since FVF provides significant income but less asset accumulation, policies must aim to connect farmers to more stable, high-value markets, thereby enhancing long-term wealth creation.

In general, the research offers empirical data that FVF is economically feasible and a livelihood-sustaining adaptation measure in waterlogged settings, yet its viability over time will require advancements in human capital, access to financial resources, and market connectivity.

Limitations of the study

The limitation of this study is acknowledged on several fronts. Firstly, the study used cross-sectional data of 120 farmers from selected regions. Therefore, the results may not be representative of other regions. Secondly, the livelihood effect was assessed based on farmers' self-reported responses, which indicated the direction of the change but not its precise level. Thirdly, the absence of a control group limits the ability to determine causality. Fourthly, the profitability analysis did not explicitly account for the variation in market prices. Finally, the regression model did not address possible endogeneity or omitted variable bias, particularly with respect to education, land size, and income. The model was primarily used to identify associations rather than to establish strict causality. To address omitted variable bias, the model included the major socioeconomic and farm-level variables identified in prior literature. Nevertheless, some endogeneity may still exist due to unobserved factors or reverse causality. Future research may use more sophisticated econometric methods to study causal relationships rigorously.

Acknowledgements

The authors acknowledge the support, time, and cooperation of the data enumerators and respondents during the data collection process.

Funding source

This paper is a part of an MS thesis conducted at the Department of Agribusiness, Gazipur Agricultural University (GAU), which was funded by the Research Management Wing (RMW) of GAU during 2023–2025 (Grant No. 026) through the project entitled "Enhancing Livelihood in Waterlogged Areas of Bangladesh through Floating Vegetable Farming: A Value Chain Analysis."

Conflict of interest

The authors confirm that there are no financial or personal conflicts of interest that could have influenced the work reported in this study.

Authors' contribution statement

Md Nazmul Islam worked as a research assistant in the RMW-funded project mentioned above. He carried out the fieldwork, data analysis, and initial drafting of the manuscript as part of his MS research. Mst Tania Parvin conceptualized the study, managed funding, supervised the MS work, and revised the paper critically. Debasish Chandra Acharjee, Armina Sarkar, and Khandakar Ramisha Anjum Misha assisted with data analysis and literature review. Synthia Islam and Yasin Ibrahim Ankon supported questionnaire development and data compilation. Md Monjurul Islam and Mst Noorunnahar provided valuable insight for statistical analysis and data tabulation. All authors reviewed and approved the final version of the manuscript.

References

Alam, K., and M. A. T. Chowdhury, 2018. Floating Vegetable Gardening (FVG) as a Sustainable Agricultural System in Bangladesh: Prospects for Kaptai Lake, Rangamati, and Chittagong Hill-Tracts. *OIDA Int. J. Sust. Dev.* 11(03), 43–58. https://doi.org/10.5198/j.oidsdev.2018.411

Al-Maruf, A. 2020. Floating gardening in coastal Bangladesh: Evidence of sustainable farming for food security under climate change. *J. Agri. Food Env.* 1(4): 161–168. https://doi.org/10.30903/2663-8820.2020.04.06

Angelsen, A., H. O., Larsen, J. F. Lund, C. Smith-Hall, and S. Wunder. 2011. *Measuring livelihoods and environmental dependence: Methods for research and fieldwork*. Earthscan. Avialable Via https://doi.org/10.17528/cifor/003341. Accessed on 20 Oct 2025.

Bala, H., A. K. Bala, M. M. H. Kazal, M. S. Rahman, M. Sultana, and M. H. K. Sujan. 2020. Floating gardening in Bangladesh: a sustainable income generating activity in wetland areas. *Int. J. Agri. Resea. Inno. Tech.* 10(1): 87-93. https://doi.org/10.3329/ijarit.v10i1.48839

Biswas, L., M. M. Islam, and S. S. Islam. 2022. Causes and consequences of livestock rearing during the fallow period of crop production. *Khulna Univ. Stu.* 19(2), 241–251.

Breusch, T. S. and A. R. Pagan. 1979. A simple test for heteroskedasticity and random coefficient variation. *Econometrica* 47(5), 1287–1294. https://doi.org/10.2307/1911963

BWDB (Bangladesh Water Development Board). 2008. *Annual Flood Report 2008*. Flood Forecasting and Warning Centre, Bangladesh Water Development Board. Available via http://www.ffwc.gov.bd/index.php/reports/annual-flood-reports. Accessed on 15 Oct 2025.

BWDB (Bangladesh Water Development Board). 2012. *Annual Flood Report 2012*. Flood Forecasting and Warning Centre, Bangladesh Water Development Board. Available via https://wbiwd.gov.in/uploads/anual_flood_report/ANNUAL_FLOOD_REPORT_2012.pdf. Accessed on 15 Oct 2025.

Chowdhury, R. B. and G. A. Moore. 2017. Floating agriculture: a potential cleaner production technique for climate change adaptation and sustainable community development in Bangladesh. *J. Cln. Prod.* 150: 371–389. https://doi.org/10.1016/j.jclepro.2015.10.055

Cochran, W. G. 1977. Sampling Techniques. 3rd ed. John Wiley and Sons, New York, USA.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3): 297–334. https://doi.org/10.1007/BF02310555

Dhali, M. Z. H., S. Sen, D. M. A. Emran, and S. A. Biswas. 2014. Impact of Floating Agriculture on Socioeconomic Condition and Bio-diversity. *Int. J. Bus. Soc. Sci. Resea.* 2(2): 173-177. https://doi.org/10.15520/ijbssr.v2i2.203

Durbin, J. and G.S. Watson. 1950. Testing for serial correlation in least squares regression. *Biom.* 37(3/4), 409–428. https://doi.org/10.1093/biomet/37.3-4.409

Gujarati, D. N. and Porter, D. C. 2008. *Basic Econometrics* (5th ed.). McGraw-Hill, New York.

Gujarati, D. N. and Porter, D. C. 2020. *Basic econometrics* (6th ed.). McGraw-Hill Educ.

Hillel, D. 2003. *Introduction to environmental soil physics*. Elsevier Acad. Press, Amsterdam. Available via https://www.google.com/search?q=https://doi.org/10.1016/B978-0-12-348655-4.50001-X. Accessed on 22 Oct 2025.

Hofman, G. J. and D. Durnford. 1999. Drainage design for salinity control. In R. W. Skaggs & J. van Schilfgaarde (Eds.), Agricultural drainage (pp. 579–614). *Agri. Drain.* Agron. Mono. 38. American Society of Agron., Madison, WI.

Hossain, M. U. 2020. Survey on common practices of vegetables cultivation in floating bed at Barishal district, Bangladesh. *ABC Res. Alert* 8(3): 99–106. https://doi.org/10.33923/j.abcra.2020.08.03.1818

Irfanullah, H. M. 2014. Floating gardening in Bangladesh: Already affected by climate variability? *Weath. Clim. Extr.* 4, 36–45. https://doi.org/10.1016/j.wace.2014.03.001

Irfanullah, H. M. 2018. Floating agriculture drifts from Bangladesh to Viet Nam. Available via IUCN. https://iucn.org/news/bangladesh/201811/blog-floating-agriculture-drifts-bangladesh-viet-nam. Assessed on 16 Oct 2025.

Islam, M. A., M. S. A. Khandoker, and S. Choudhury. 2019. Constraints of floating farming in Haor area of Bangladesh. *Int. J. Agri. Sci.* 9(9), 001–005. https://doi.org/10.5963/ijass-1810604023092019

Jahan, N. and D. Khanam. 2020. Floating Vegetable Cultivation: A Sustainable Livelihood Strategy for Flood Prone Areas of Bangladesh. *Glo. J. Hum. Soc. Sci.* 20(9), 20–27.

Karakasidou, S., A. Charakopoulos, and L. Zachilas. 2024. Investigating system dynamics of vegetable prices using complex network analysis and temporal variation methods. *AppliedMath* 4(4), 1328–1357. https://doi.org/10.3390/applymath4040062

Kutner, M. H., C. J. Nachtsheim, and J. Neter. 2004. *Applied Linear Regression Models* (4th ed.). McGraw-Hill/Irwin, New York.

Liswanti, N., B. Shantiko, E. Fripp, E. Mwangi, and Y. Laumonier. 2012. Practical guide for socioeconomic livelihood, land tenure, and rights surveys for use in collaborative ecosystem-based land use planning. Available via CIFOR. https://doi.org/10.17528/cifor/004030. Accessed on 22 Oct 2025.

Mirza, M. 2003. Climate change and extreme weather events: can developing countries adapt? *Clim. Pol.* 3(3): 233–248. https://doi.org/10.3763/cpol.2003.0330

MoF (Ministry of Finance). 2024. *Bangladesh Economic Review.* Finance Division, Ministry of Finance, Government of Bangladesh. Available via MoF. https://www.google.com/search?q=https://mof.gov.bd/site/view/budget_mof/%25E0%25A7%25A8%25E0%25A7%25A6%25E0%25A7%25A8%25E0%25A7%25A8-%25E0%25A7%25A8%25E0%25A7%25A9/%25E0%25A6%2586%25E0%25A6%25B0%25E0%25A7%258D%25E0%25A6%25B7%25E0%25A6%BE/Bangladesh-Economic-Review. Accessed on 15 Oct 2025.

Mohsin, K. F. and T. Ferdousi. 2019. Role of floating cultivation on rural livelihood practice of coastal Bangladesh. *Khulna Univ. Stu.* 16(2), 89–102.(https://www.google.com/search?q=https://doi.org/10.53808/KUS.2019.16.02.0125-AS)

Nunnally, J. C. 1978. Psychometric Theory. 2nd ed. McGraw-Hill, New York, USA.

Physi. 2024. The floating vegetable gardens of Bangladesh. In: *Urban Nat. Atlas.* Retrieved October 15, 2025, from https://urban-nature-atlas.com/case-study/the-floating-vegetable-gardens-of-bangladesh

Practical Action. 2021. *Floating Gardens – A transformative, accessible approach to agriculture.* Available via Practical Action. https://practicalaction.org/publications/. Accessed on 15 Oct 2025.

Rahman, M. M., D. Zhou, S. Barua, M. S. Farid, and K. T. Tahira. 2020. Challenges of value chain actors for vegetable production and marketing in North-East Bangladesh. GeoJ. 86(4): 1957–1967. https://doi.org/10.1007/s10708-020-10170-y

Rana, M. S. 2018. Floating vegetable gardening in Bangladesh: A way to improve income and livelihood of the farmers. (MS Thesis, Department of Development and Poverty Studies). *Sher-E-Bangla Agri. Univ.* https://doi.org/10.2139/ssrn.4301441

Sakib, M. H. and M. S. I. Afrad. 2014. Adoption of modern aquaculture technologies by the fish farmers in Bogra district of Bangladesh. *Int. J. Agri. Inno. Res.* 3(2): 414-421.

Sarker, M. R., N. D. Kundu, M. H. K. Sujan, Md. Salman, A. M. McKenzie, M. M. Islam, M. A. Rahman, M. T. Uddin, H. Bhandari, and M. A. R. Sarkar. 2025. River waste to goldmine: A tale of floating agriculture in vulnerable Southern regions of Bangladesh. *Food Ener. Sec.* 14(2), e70062: 1–24. https://doi.org/10.1002/fes3.70062

Statista. 2025. *Vegetables - Bangladesh.* Available via https://www.statista.com/outlook/cmo/food/vegetables/bangladesh. Accessed on 19 Mar 2025.

White, H. 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica*, 48(4): 817–838. https://doi.org/10.2307/1912934

Wooldridge, J. M. 2019. *Introductory econometrics: A modern approach* (7th ed.). Cengage Learning. Available via https://www.cengage.com/c/introductory-econometrics-a-modern-approach-7e-wooldridge/. Accessed on 22 Oct 2025.

Yang, H., Y. Cao, Y. Shi, Y. Wu, W. Guo, H. Fu and Y. Li. 2022. The dynamic impacts of weather changes on vegetable price fluctuations in Shandong Province, China: an analysis based on VAR and TVP-VAR models. *Agron.* 12(11), 2680: 2–27. https://doi.org/10.3390/agronomy12112680

Yasmin, M., M. K. Alam, H. R. Khan, and A. K. M. A. Islam. 2013. Adoption of modern rice varieties in selected areas of Bangladesh. *J. Bangladesh Agri.* 3(2): 101–109. https://doi.org/10.3329/jba.v3i2.17937.