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Socioeconomic characteristics and profitability analysis of commercial mango cultivation in the Rajshahi region of Bangladesh

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ABSTRACT

Mango cultivation is a vital source of agricultural income and a key contributor to rural livelihoods in Bangladesh. To better understand the economic potential of this sector, data were collected through a structured interview schedule with 240 commercial mango growers from the central mango-producing region of Rajshahi, Bangladesh, during the 2023-2024 season. A stratified random sampling method was used to account for differences in farm size and resource use. The socioeconomic status of the farmers was profiled using descriptive statistics, while costs and revenues were estimated through enterprise budgeting techniques. Factors influencing mango income were identified using multiple linear regression. The findings reveal that most farmers are middle-aged, manage an average of 1.45 hectares of orchard land, and possess a moderate level of education, with limited access to training and credit facilities. Production primarily involves grafted trees of BARI Aam-3, Himsagar, and Langra varieties, with basin irrigation and pesticide use being standard practices. Despite the high costs of pesticides and hired labor, the average yield was 20.54 tons per hectare, resulting in a profit-to-cost ratio of 2.03, which confirms mango farming as a profitable venture. Regression analysis reveals that larger landholdings, land ownership, and participation in training significantly enhance mango income, whereas education and farming experience have notable adverse effects on mango income. Other factors such as age, household size, and access to credit were not found to be statistically significant. These insights underscore the importance of expanding training programs, enhancing land-use efficiency, and developing targeted interventions for older and resource-constrained households to improve the profitability and sustainability of mango cultivation.

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Introduction

Mango (*Mangifera indica* L.) is one of the most significant tropical fruits globally, widely cultivated for its nutritional value, cultural significance, and impact on the rural economy (Gaurav *et al*., 2021; Rahman and Khatun, 2018). In Bangladesh, the mango holds a special position, often referred to as the "king of fruits" and a lucrative cash crop for smallholder farmers (Akotsen-Mensah *et al.,* 2017; Hoque *et al.,* 2023). Due to favorable agro-ecological conditions, Bangladesh has become one of the leading mango producers, serving significant domestic markets and opening up export opportunities (Zayed, 2022; Sampa *et al.,* 2019). Mango cultivation is more profitable than other field crops (Hasan *et al.,* 2025; Rahman *et al.,* 2019). The fruit plays a vital role in supporting rural livelihoods by creating jobs in cultivation, harvesting, transportation, and marketing (Balaganesh and Makarabbi, 2023; Teyung and Luitel, 2022). Mango farming is not only financially beneficial but also socially valuable, as it helps small and medium-sized farmers diversify their income sources and enhance household food security (Rahman *et al.,* 2012; Teyung and Luitel, 2022). However, the profitability and sustainability of mango production rely on several key factors, including access to land, labor, technology, credit, and the socio-economic status of farmers (Haldar, 2022). These elements collectively influence farmers' ability to adopt better practices, meet market demands, and optimize returns from their crops. As a result, studying the socio-economic factors affecting mango production outcomes has a significant impact on agricultural policy, rural development, and poverty reduction in Bangladesh.

A growing body of research has highlighted the profitability and potential of mango cultivation in South Asia and beyond (Hamidah, 2023; Singh, 2020). Studies in India and Pakistan have shown that mango cultivation is generally profitable, with a Benefit-Cost Ratio ranging from 1.98 to 3.94, indicating that investing in mango production is economically viable (Vasuki and Soundariyan, 2022; Kumar *et al.,* 2019). In Bangladesh, research by Islam et al. (2019) and others has confirmed that most mango farmers are middle-aged with moderate education levels and engage in mango farming as either their primary or supplementary occupation (Patel and Patel, 2020; Sampa *et al.*, 2019; Chinchmalatpure *et al.,* 2013; Haq, 2012). Farmers typically rely on grafted seedlings from nurseries, and sometimes practice intercropping to generate additional income. Several studies emphasize that training, extension services, and access to inputs are crucial for improving yield and profitability (Kalogiannidis and Syndoukas, 2024; Mburu *et al.,* 2023; Raji *et al*., 2024). Additionally, the choice of variety significantly influences economic outcomes, with varieties such as BARI Aam-3, Himsagar, and Langra offering advantages in taste, market demand, and disease resistance (Anu *et al.,* 2015; Singh and Agrawal, 2019; Vinodh *et al*., 2025). International literature identifies

socio-economic factors such as education, farming experience, and land size as strong predictors of technology adoption and farm income (Javed and Zahra, 2023; Okidim *et al*., 2023; Choudhury *et al*., 2018; Zegeye *et al.*, 2022). Empirical studies employing econometric models have also demonstrated that access to credit, institutional support, and extension contacts are key factors shaping the profitability and sustainability of perennial fruit crops (Biradar *et al*., 2024; Moahid *et al*., 2021; Ntabakirabose *et al*., 2021; Sabasi *et al*., 2021).

Mango is a perennial fruit crop that requires substantial initial investment, a long gestation period, and many years of management before full yield is achieved, unlike other annual crops. Therefore, economic returns from mango cultivation depend not only on the inputs and outputs of the current season, but also on the choice of variety, the age of the orchard, and the growers' long-term management capabilities. Mango varieties, such as BARI Aam-3, Himsagar, and Langra, differ significantly in terms of yield behavior, market timing, and yield stability, which makes profitability analysis more complex than that of seasonal crops. However, most existing studies in Bangladesh treat mango production as a short-term venture, ignoring its perennial nature (Zayed, 2022; Rahman *et al.,* 2019). The study fills that gap by examining socio-economic determinants and profitability in the context of commercial mango cultivation.

Despite increasing research, several limitations remain in the existing literature on mango production in Bangladesh. Most of the earlier work, such as (Fuentes Figueroa *et al.*, 2024; Rahman *et al.,* 2019), has focused on descriptive aspects, including documenting production methods, popular varieties, or gross profitability, while failing to establish rigorous statistical links between farmers' socio-economic status and their economic gains. Additionally, studies often rely on aggregate or regional data that mask intra-household differences in resource use, access to finance, and training opportunities (González and Valderrama, 2023; Houensou *et al.,* 2021). Very few research has used econometric analysis, such as multiple linear regression, to quantitatively assess how factors like education, farm size, farming experience, training, and credit access influence farmers' income from mango farming. This lack of analytical depth limits the policy relevance of past studies, as policymakers and development agencies need clear evidence of socio-economic drivers of profitability to design targeted interventions. In this context, the current research seeks to address these gaps by combining detailed descriptive statistics with econometric modeling. Specifically, it analyzes the socio-economic characteristics of mango farmers, estimates profitability and profit-cost ratios, and applies multiple linear regression to explore the relationship between farmers' attributes and their income from mango cultivation. The uniqueness of this study

lies in its district-level focus, comprehensive dataset, and integration of econometric tools to identify key income determinants. By doing so, the study makes both a theoretical contribution to the agricultural economics literature and provides practical insights for extension services, financial institutions, and policymakers seeking to promote sustainable mango farming in Bangladesh. That's why the specific objectives of this research are:

- to assess the socioeconomic characteristics of the mango growers;
- to examine the production practices, profitability, and benefit-cost ratio of mango production; and
- to analyze the relationship between farmers' socioeconomic characteristics and their income from mango cultivation.

Materials and Methods

Research design and study area

The present study followed a descriptive and diagnostic research design (Hasan *et al.,* 2022; Hasan *et al.,* 2023). The research design employed a combination of both qualitative and quantitative approaches. The qualitative insights were gathered through field observations, key informant interviews (KIIs), and focus group discussions (FGDs). The research was conducted in the Rajshahi Division. From there, Shibganj Upazila of Chapainababganj District, Bagha Upazila of Rajshahi District, and Bagatipara Upazila of Natore District were purposively selected (Fig. 1). The study area was chosen due to its concentration of commercial mango orchards,

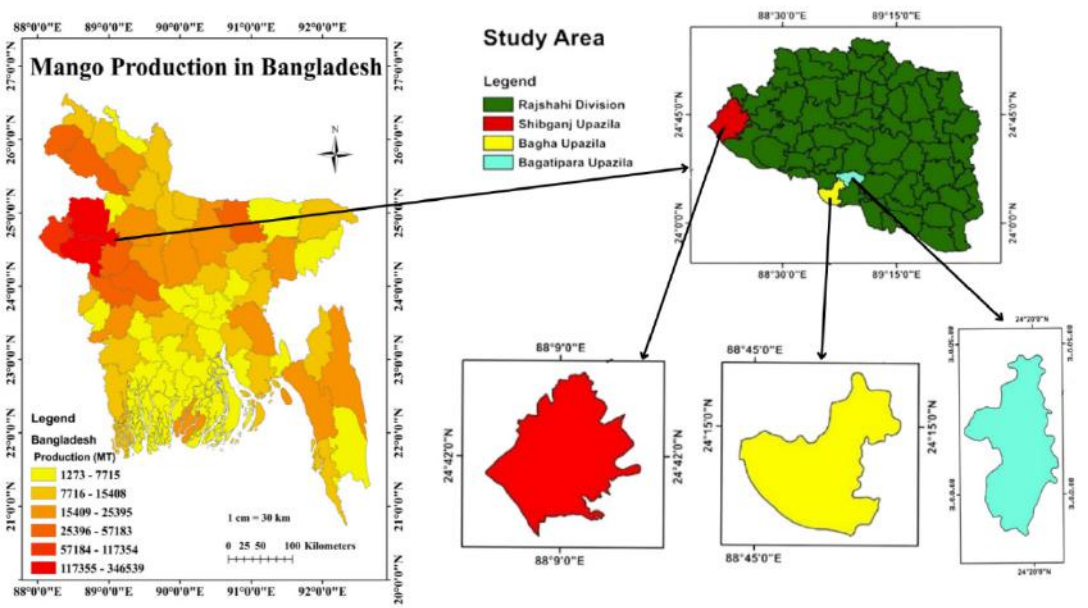

Fig. 1. Map showing the study area.

favorable agro-ecological conditions, and relevance to the national mango value chain.

Sampling procedure and selection of respondents

The target population of the study consisted of all commercial mango growers, numbering 653, in the selected districts. To ensure representativeness, a multi-stage sampling technique was adopted. At first, based on mango production intensity, districts were purposively selected. Secondly, the high intensity of mango orchards was identified in upazilas and villages with the help of local sub-assistant agricultural officers. Finally, to determine commercial farmers from village-level lists of commercial mango growers, a stratified random sampling technique was employed.

According to Cochran's (1977) formula, a total sample from commercial mango growers was determined, with a 95% confidence interval and an allowable error margin of 5%.

Data collection tools and techniques

For collecting primary data, a pre-tested interview schedule was developed. The schedule was divided into different sections, each containing socioeconomic characteristics, landholding and resource endowments, training and extension exposure, access to finance, production practices, varietal choice, inputs, and outputs, marketing channels, and other relevant factors. From those data gross returns, gross margin, net return, and the benefit-cost ratio (BCR) were calculated.

Four focus group discussions (FGDs), each comprising 8-10 mango growers, were conducted in addition to household surveys to capture the collective perceptions of challenges, opportunities, and experiences associated with mango production. Key informant interviews (KIIs) were also conducted with extension agents, nursery owners, and local traders to validate farmer responses and provide triangulated data. Field observations were also conducted to document orchard management practices and post-harvest handling.

Analytical framework

Standard methods were employed to evaluate the socioeconomic components (Hasan *et al*., 2025; Hasan *et al*., 2023; Hoque *et al*., 2023). Descriptive statistics, including mean, standard deviation, frequency, and percentage, were used to summarize farmers' demographic characteristics, training exposure, varietal choices, and input use patterns. These results provided a profile of mango growers in the study area and served as a foundation for subsequent analysis.

Profitability analysis

Although mango is a perennial fruit, the present study adopts a cross–sectional farm-level approach based on data collected for a single production season. Due to the absence of reliable year-wise information on establishment costs, gestation period returns, and long-term yield streams, discounted cash flow techniques such as Net Present Value (NPV) and Internal Rate of Return

(IRR) could not be applied. Therefore, conventional enterprise budgeting indicators, such as gross margin, net return, and benefit-cost ratio, were used to assess short-term profitability, following standard practice in farm management studies based on cross-sectional data.

Gross Return (GR): Total harvested yield (kg/ha) * Price (Tk/kg)

Total Variable Cost (TVC): It includes costs for labor, fertilizers, irrigation, pesticides, transport, saplings, and other variable inputs.

Gross Margin (GM): GM = GR – TVC

Total Cost (TC): TC = TVC + Fixed costs (land rent + planting material)

Net Return (NR): NR = GR- TC

Benefit – Cost Ratio (BCR): BCR = GR / TC

Econometric Model: To analyze the relationship between farmers' demographic characteristics and their income from mango cultivation, a multiple linear regression model was specified:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + ... + \beta_k X_{ki} + \epsilon_i$$

Where:

Y_i = Income from mango production for farmer i

X_{1i}……X_{ki} = Vector of independent variables representing farmers' demographic characteristics

β_0 = Intercept

β_1……β_k = Coefficients measuring the marginal effect of each explanatory variable.

ϵ_i = Random error term

The following explanatory variables were included in the model: Age of farmer (years), household size (persons), education level (years of schooling), landholding size (hectares), farming experience (years), primary occupation (dummy: agriculture = 1, otherwise = 0), training received (dummy: yes = 1, no = 0), access to credit/loan (dummy: yes = 1, no = 0).

Income was measured in Bangladeshi Taka (BDT) per hectare, adjusted to USD for comparison. The regression analysis was conducted using R software.

Results and Discussion

Sample characteristics

Among the 240 mango farmers, all were male with an average age of 41 years. In comparison to the national average of 4.1, the average household size was 5 (BBS, 2022). 85.0 percent of the respondents were literate with an average of 8.18, which is impressive. The average total cultivated land area was 1.45 ha, of which 67.91 percent of respondent had their land. The alarming issue is that only 9.17 percent of respondents received training in mango cultivation. For 77.9 percent of the respondents, agriculture was their primary line of work. Others (22.1%) were businessmen, drivers, service providers, tailors, and teachers who also cultivated mangoes commercially or

Table 1. Characteristics of the sample farmers of mango-growing regions of Bangladesh

Household characteristics	Mean	SE
Age (Years)	40.84	0.69
Size of household (persons)	4.83	0.11
Education (years)	8.18	0.27
Area of all cultivated land (ha)	1.45	0.07
Owned cultivated land area (percent)	67.91	
Training received (percent)	9.17	
Primary occupation in agriculture (percent)	77.9	
Primary occupation outside agriculture (percent)	22.1	
Years of commercial mango production	8.92	0.34
Access to credit (percent)	45.4	

Source: (Author's calculation, 2025)

for their own consumption. The majority of respondents (72.1%) had an average of 8.92 years of experience in commercial mango production (Table 1). Islam *et al.* (2019) found similar socio-demographic characteristics in their study. The mango production method is reliable and profitable, as evidenced by the average duration of commercial cultivation, which is approximately nine years. It was also found that for increased mango production, 45.4 percent of the respondents had access to take credit from various donor organizations (NGOs, banks, cooperative societies).

Production of mango

The ideal soil and weather conditions of the

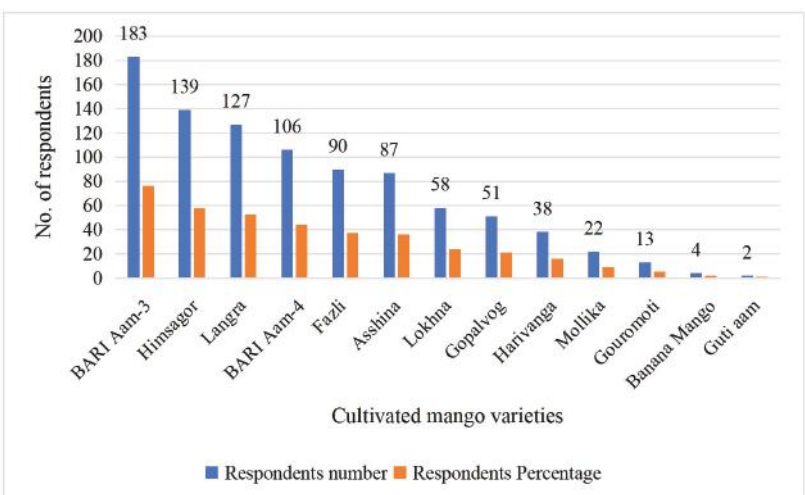

Fig. 2. Distribution of the respondents according to different mango variety production

research area support Mango cultivation. Of the numerous variations, thirteen were grown for commercial purposes. Fig. 2. illustrates that the BARI aam-3 variety is cultivated by the most significant percentage of respondents (76.25%), placing it in first place. BARI Aam-3 variety is a substantial introduction to the nation's mango scene. The fruit has a delightfully aromatic sweetness with late and regular bearing.

Himsagor, also known as Khirsapati, came in second place because (57.92%) of respondents cultivated this type. This cultivar of mango is famous. Himsagar's insides are fibreless and range in color from yellow to orange. It has a high level of durability (Kochhar, 2011).

Langra came in third place since 52.92 percent of respondents grew this cultivar. Its versatility for canning and slicing has led to its increasing popularity on the international market these days (Evans, 2008).

BARI Aam-4 ranked 4th among the commercial cultivars, containing 44.16 percent of respondents. It is a late-blooming, sweet variety with an impressive yield that fruits regularly. The size of this fruit is large, and it has a very sweet taste. Truly sweet in raw form. It is growing in popularity daily because farmers who plant it later receive favorable market prices.

Fazli, Asshina, Lokhna, Gopalvog, Harivanga, and Mollika were also popular in the study location due to their unique taste, ripening time, and market demand. Some farmers also

Table 2. Features of the mango production in selected regions of Bangladesh, 2023-2024

Items	Number	Percent
Planting material type (% of all farmers)		
- Saplings (using different kinds of grafting)	240	100
- Seedlings (grown from seed without grafting)	0	0
Source of saplings (% of all farmers)		
-Nursery	194	80.8
-Market	38	15.8
-Neighbor	7	2.9
-Own	1	0.4
Companion crop cultivated (% of all farmers)		
-Yes (Ginger, Guava, Lentil, Tomato, Turmeric)	76	31.7
-No	164	68.3
Received training in disease management		
-Yes	13	5.4
-No	227	94.6

Source: (Author's calculation, 2025)

Table 3. Mango production costs and output, 2023-2024 in US dollars/ha

Items	Mean	SD	% of total cost
Costs:			
A. Cost variance (without IOC):	2,926	5,406	80.32
- Pit preparation	198	389	5.44
-Purchase of saplings	239	502	6.56
-Organic fertilizers	176	624	4.83
-Inorganic fertilizers	240	341	6.59
-Irrigation	147	261	4.04
-Hormone for breaking alternate breaking	51	133	1.40
-Inorganic pesticides	1,338	2,116	36.73
-Bagging	22	75	0.60
-Hired labor	354	648	9.72
-Transport cost	161	317	4.42
Interest on operating Capital (10% for 6 months)	146	-	4.01
A′. Total variable cost (A + IOC)	3,072	5,406	84.33
B. Fixed cost:	570	1,275	15.67
-Opportunity cost of land	408	866	11.20
-Planting material cost	162	409	4.47
C. Total cost (A′ + B)	3,642	6,681	100.00
Returns:			
Total harvested yield (t/ha)	20.544	9.40	
D. Output value	7375	9698	
Profitability:			
G. Gross margin (D − A′)	4,303	4,292	
H. Net return (D − C)	3,733	3,017	
Benefit–cost ratio (BCR) (D/C)	2.03	1.45	
% of farmers with a positive net return	100		

* Notes: 1 USD = 110 TK. The rent a farmer may receive was used to determine the opportunity cost of owning land. Interest on Capital (IOC)= 10% per year. *Source: (Author's calculation, 2025)*

cultivate Gouromoti, Banana mango, and Guti aam on a small scale.

Salient features of mango production

According to the results shown in Table 2, a cent percent of the farmers used saplings rather than seed to develop a new garden. For these 2 to 3-year olds, veneer or craft seedlings are the best suited for planting. The majority (80.8%) of respondents collected their saplings from different reliable nurseries, such as BADC nursery and horticulture nursery. Others used to collect their seedlings from the local market or a neighbor. Less

than one-third of the respondents (31.7%) practice intercropping. In that case, Ginger, Guava, Lentil, Tomato, and Turmeric were used as companion crops. Respondents who practice intercropping get extra benefits from the same land (Swain, 2014). Approximately 5.4 percent of the respondents have training on managing mango diseases, which needs to be improved for better profitability.

Benefit-cost ratio

The estimated profitability indicators reflect short-term operational performance rather than long-term investment viability. Given the perennial nature of mango cultivation, these results should be interpreted as indicative of annual enterprise efficiency under existing management operations. Using inorganic pesticides accounted for (36.73%) of the overall cost of mango production, making it the highest single variable cost (Table 3). The expenses for hired labor (9.72%), inorganic fertilizers (6.59%), and supplies for seeds, saplings/nursery supplies (6.56%) followed. Pit preparation (5.44%), organic fertilizer (4.83%), transport cost (4.42%), and irrigation (4.04%) occupied 5th, 6th, 7^{th,} and 8th place, respectively. Respondents use only (2.0%) of their total cost in hormone application (1.40%) and bagging (0.60%). Interest on operating capital was calculated at the rate of 10 percent per annum for a period of six months, which constituted (4.01%) of the total cost of mango production. It was assumed that operating capital remained invested on average for half of the production year, as variable expenses such as fertilizers, pesticides, irrigation, and labor are incurred gradually from flowering to harvest. A total of (15.67%) of the production expenses were attributed to fixed costs, which comprised the opportunity cost of land and planting material costs.

Mango yield was 20.54 t/ha on average in the selected areas. The overall seasonal gross margin and net return per hectare were estimated to be USD 4,303 and USD 3,733, respectively. The benefit-cost ratio indicated that respondents earned $ 2.03 for every $1 invested in mango cultivation. Almost a cent of the respondents reported making profits from the production of mangos during that season. Bakhsh *et al*. (2006), demonstrated in their study that investment in mango farming can be deemed significant and economically justified, with a BCR of 2.61.

Farmers' knowledge of mango cultivation technology

Due to environmental and varietal conditions, combined with orchard management techniques such as fertilization, irrigation, pruning, and plant protection, alternate or irregular bearing of mango is often observed (Kumar *et al.*, 2021). According to Shivran *et al.* (2020), mango alternative bearing needs to be controlled for orchard profitability. That's why control measures, such as the application of PGRs, pruning, weeding, and thinning of fruits, were implemented (Jangid *et al*., 2023). Farmers were questioned about their knowledge of this issue and whether

Table 4. Farmers' knowledge of the general cultivation technology of mango in Bangladesh

Major operations	Number	Percent
Pre-harvest operations		
-Alternate bearing of mango	193	80.4
-Use a hormone to remove alternate bearing	104	43.3
-Pruning	115	47.9
-Weeding	189	78.8
Irrigation		
- After complete flowering, when the fruit is pea-seed-like	192	80.0
-Basin method of irrigation	222	92.5
Fertilization		
- After the rainy season but before October	151	62.9
- Fertilize after pea seed like fruit setting	89	37.1
Techniques of harvesting mango		
-By hand	205	85.4
-By stick	184	76.7
-Shaking the tree	02	0.8
Post-harvest operations		
-Cooling (Lay it on the ground for some time)	81	33.8
-Grading & Packaging (put into carat)	178	74.2

Source: (Author's calculation, 2025)

they used hormone spraying to solve it. The majority (80.4%) of respondents have a clear understanding of alternate bearing, and to combat this problem, 43.3% of them spray hormones to break the phenomenon. This hormone spraying is especially prevalent among large commercial growers, rather than small growers who cultivate mangoes to fulfill their own consumption. To manage the growth of the canopy and generate premium, marketable fruits, (47.9%) respondents remove the bearing surface, or fruit buds. 78.8 percent of the respondent also practice weeding in their mango field as an intercultural practice. In case of irrigation, the majority (92.5%) choose the basin method, and (80.0%) irrigate after flowering when the fruit is pea seed-like. Most of them (62.9%) finish fertilizing before October and soon after the rains end.

Three different methods are employed by farmers to harvest mangoes from trees. The hand-picking method (85.4%) is the most often used of the three techniques, and it is the safest choice for small trees. Mangos are also harvested using a specially made long pole and stick. However, people must take precautions to avoid being injured while gathering mangoes. In the case of mangos, mechanical harvesting proved effective in reducing quantitative loss while maintaining

postharvest quality and significantly extending shelf life (Prasad *et al*., 2019).

Several post-harvest procedures are carried out after the mangoes are harvested from the tree. Mango growers typically sell their entire orchards to Farias or middlemen. Mangos are harvested by them and then put into crates for marketing. This technique is followed by the majority (74.2%) of the respondents. After picking the mango from the tree, 33.8 percent of the respondents placed it on the ground. This is due to the better air circulation around each fruit, which can help prevent mold and rot.

Factors influencing respondents' income from mango cultivation

Eight independent variables were considered to identify the determinants of income among mango growers through regression analysis. Regression results presented in Table 5 indicated that four out of the eight characteristics, education, farmer type, training received, and farm size, showed significant contributions to the income levels of mango growers.

According to the R^2 value of 0.602, the chosen attributes may account for roughly 60.2% of the variation in respondents' income. The model's robustness is confirmed by the corrected R^2 value of 0.588. The extremely significant F value of 43.70 ($p < 0.001$) indicates that the regression model fits the data well. The Durbin-Watson statistic for this analysis is 1.826, indicating that the errors are independent. With no multicollinearity (VIFs < 1.5), coefficient stability is supported. Leverage is at most moderate (max centered leverage = 0.146), and standardized residuals fall primarily within ±3 (range –3.017 to 7.095) and Cook's D had a maximum of 0.59, indicating no undue impact. Fit and diagnostics are generally suitable for inference.

Table 5. Influence of selected characteristics on the income of the mango growers

Characteristics of the respondents	Standardized Coefficient (β)	Coefficient (B)	t-value	p-significant
Age (years)	-0.0665	-4032.32	-1.3875	0.167
Household size (persons)	-0.0634	-24541.20	-1.4244	0.156
Education (years)	-0.1035	-15921.36	-2.3943	0.017**
Farmers type (1=owner)	0.1010	75443.03	2.2939	0.023**
Training received (1=yes)	0.0865	77168.39	1.9842	0.048**
Farming experience (years)	-0.0794	-9844.66	-1.6677	0.097*
Farm size (ha)	0.7268	439220.96	16.7426	0.000***
Access to credit (1=yes)	0.0140	18832.50	0.3293	0.742

R^2=0.602, Adjusted R^2=0.588, value of F= 43.70, *p < 0.10, **p < 0.05, ***p < 0.01.

Farm size had a highly significant and positive impact on income ($p < 0.01$), with a standardized coefficient (β) of 0.727 and an unstandardized coefficient (B) of 439,220.96. This suggests that, among the other predictors, farm size is the most significant factor influencing income. Large landholdings enable growers to plant mango orchards on a larger scale, employ better management practices, and benefit from economies of scale. This finding aligns with predictions. In addition to increasing overall profitability, farmers with additional land can diversify their output and lower unit costs. This is consistent with past research that highlighted land size as a crucial factor influencing farm revenue (Novianty and Awaliyah, 2022). But Mondal and Sen (2023) and Helfand and Taylor (2018) highlighted inverse and U-shaped relationships in their studies.

Education had a significant negative effect ($\beta = -0.104$, $B = -15{,}921.36$, $p < 0.05$). This suggests that higher-educated farmers may allocate more time to off-farm employment or other activities, thereby reducing their focus on mango cultivation and decreasing their income.

Farmers' type (owner vs. non-owner) had a significant positive effect on income ($\beta = 0.101$, $B = 75{,}443.03$, $p < 0.05$). Ownership of the farm enables better decision-making, efficient resource management, and potentially higher profitability compared to tenant or sharecropping arrangements.

Additionally, training had a significant and favorable impact on income ($\beta = 0.087$, $B = 77{,}168.39$), with a p-value of 0.05. Training helps mango growers become more technically proficient, manage their orchards more effectively, and understand how to employ the latest inputs. Furthermore, it makes people more aware of market prospects and quality standards, which boosts output and profitability. As a result, trained farmers are better equipped to implement enhanced methods and promotional tactics, which significantly increase their revenue (Solehudin, 2024; Dadashi and Gholami, 2011).

Farming experience showed a marginally significant negative effect on income ($\beta = -0.079$, $B = -9{,}844.66$, $p < 0.10$). While experience generally contributes positively through technical knowledge and market connections, in this context, it may reflect adherence to traditional practices and a reluctance to adopt modern technologies, which slightly reduces income.

Age, household size, and access to credit were not statistically significant. Even yet, it is usually assumed that these variables could theoretically influence income through labor availability and decision-making ability; however, their effects were not strong enough to be significant in this study.

Conclusions

The study of mango growers in the selected

region highlights the socioeconomic features underlying their production activities. The findings indicate that most farmers are middle-aged, have small farms averaging 1.45 hectares in size, and possess moderate educational levels. Although agriculture remains their main activity, fewer than half have access to formal credit institutions and limited training facilities. Based on the overall profile, mango growers have limited institutional support, minimal exposure to capacity-building opportunities, and scarce resources, all of which affect their production choices and revenue opportunities.

Mango cultivation is economically viable in the study region, as assessed by production methods, profitability, and the benefit-cost ratio. Most farmers use grafted plants and focus on popular varieties, such as BARI Aam-3, Himsagar, and Langra, employing basin irrigation and inorganic pesticides as their primary inputs. Despite relatively high input costs for hired labor and pesticides, average yields of 20.54 tons per hectare remain promising. Mango farming is not only profitable but also competitive compared to many other crops, with an estimated benefit-cost ratio of 2.03, ensuring growers a substantial gross margin and net return per hectare. These results support the notion that growing mangoes is a significant source of income in the studied areas.

The econometric analysis further clarifies the impact of socio-economic and demographic factors on mango income. While larger landholdings, ownership of land, and participation in training significantly enhance earnings, higher education and farming experience are linked to lower income, whereas age, household size, and access to credit show no strong direct influence. Collectively, these findings suggest that enhancing land-use efficiency, expanding farmer training, and providing targeted support for elderly and resource-constrained households are crucial policy levers to maximize the financial potential of mango farming.

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Conflict of Interest

The authors declare no conflict of interest in this work.

Author Contributions

Conceptualization: Shahriar Hasan and Md. Abdul Kader; Methodology: Shahriar Hasan, Md. Safiul Islam Afrad; Software: A. K. M. Mahmudul Hasan; Validation: Shahriar Hasan, Md. Safiul Islam Afrad. and Md. Abdul Kader; Resources: Md. Safiul Islam Afrad. and Md. Abdul Kader; Data curation: A. K. M. Mahmudul Hasan; Writing—preparation

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References

Akotsen-Mensah, C., I. N. Ativor, R. S. Anderson, K. Afreh-Nuamah, C. F. Brentu, D. Osei-Safo, A. Asuming Boakye and V. Avah. 2017. Pest management knowledge and practices of mango farmers in southeastern Ghana. *J. Integr. Pest Manag.* 8(1): 13. https://doi.org/10.1093/jipm/pmx008.

Anu, A., B. D. Prasad, R. Kumar, P. Kumar, V. B. Patel and R. N. Jha. 2015. Clonal variability studies in 'Langra' mango (Mangifera indica L.) using morphological, biochemical and molecular markers. *Int. J. Agric. Environ. Biotechnol*. 8(3): 567–581. https://doi.org/10.5958/2230-732X.2015.00063.7.

Bakhsh, K., I. Hassan and M. S. Akhter. 2006. Profitability and cost in growing mango orchards. *J. Agric. Soc. Sci*. 2(1): 1813–2235.

Balaganesh, G. and G. Makarabbi. 2023. An analysis on performance of mango production in India. *Asian J. Agric. Ext. Econ. Soc*. 41(10): 968–976. https://doi.org/10.9734/ajaees/2023/v41i102250.

BBS. 2022. Statistical Yearbook of Bangladesh. Bangladesh Bur. Stat. (BBS), Govt. People's Repub. Bangladesh, Dhaka.

Biradar, A., P. Tevari, G. B. Lokesh, D. Beeraladinni and S. Kammar. 2024. Economic analysis of credit utilization pattern and credit gap for grape cultivation and value addition (raisin making) in Vijayapura District of Karnataka, India. *J. Exp. Agric. Int*. 46(8): 252–262. https://doi.org/10.9734/jeai/2024/v46i82702.

Chinchmalatpure, U. R., P. B. Umale and P. P. Bhople. 2013. Socio-economic impact of mango cultivation promoted under dry land horticulture programme. *J. Community Mobil. Sustain. Dev.* 8(2): 223–226.

Choudhury, B. N., S. Ch. Das, M. Ch. Sarmah and M. Ahmed. 2018. Influence of socio-economic factors on knowledge and technology adoption of sericulture farmers of Aizawl district of Mizoram. *Int. J. Adv. Res. Ideas Innov. Technol*. 4(3): 001–004. https://www.ijariit.com/manuscripts/v4i3/V4I3-1137.pdf.

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

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

Dadashi, M. A. and H. Gholami. 2011. Statistical study of promotion rice cultivation training program from aspect of rice farmers in Guilan Province. Adv. Environ. Biol. 5: 2080–2084.

Espinosa González, A. O. and J. G. Morales Valderrama. 2023. Producción de mango y su impacto en el bienestar económico y social de los fruticultores de Acapetahua, Chiapas. *Textual*. 81: 73–91. https://doi.org/10.5154/r.textual.2022.81.04.

Evans, E. A. 2008. Recent trends in world and US mango production, trade, and consumption. *EDIS*. 2008(6): 1–8. https://journals.flvc.org/edis/article/download/117438/115531.

Fuentes Figueroa, T., W. Narváez Campana, F. Ayón Villao, M. Cabrera and C. Leon Karla Meylin. 2024. Agro-socioeconomic characterization of mango production units in Pedro Carbo Canton, Ecuador. *Ciencia Latina*. 8(5): 2818–2833. https://doi.org/10.37811/cl_rcm.v8i5.13746.

Gaurav Papnai, P. N., N. J. V. Supyal and R. Bhaskar. 2021. Intervention of high density plantation of mango in lower hills for doubling farmers' income. *Int. J. Curr. Microbiol. Appl. Sci*. 10(2): 696–700. https://doi.org/10.20546/IJCMAS.2021.1002.083.

Haldar, G. 2022. Economic significance behind of the mango cultivation of the Malda district in West Bengal: Case study in English Bazer Block, Malda District. *SFS*. 9(1): 1–10. https://doi.org/10.53555/sfs.v9i1.2007.

Hamidah, E. 2023. Financial feasibility and business economics of Manalagi mango cultivation. *J. Agrinika*. 7(2): 97–111. https://doi.org/10.30737/agrinika.v7i2.4905.

Hasan, S., M. S. I. Afrad, M. Z. Hoque and S. Saha. 2023. Use of social media by farmers in Gazipur district of Bangladesh. *Ann. Bangladesh Agric*. 27(1): 105–120. https://doi.org/10.3329/aba.v27i1.70957.

Hasan, S., M. S. I. Afrad, S. Saha, M. R. Islam and M. A. Kader. 2025. Mango farmers' knowledge and management of anthracnose disease in Rajshahi Division, *Bangladesh. J. Agric. Ext.* 29(3): 154–162. https://doi.org/10.4314/jae.v29i3.15.

Hasan, S., S. S. Hasan, S. Saha and M. R. Islam. 2022. Identify problems and suggest possible solutions for safe pineapple production in Madhupur Tract. *Eur. J. Agric. Food Sci*. 4(5): 68–74. https://doi.org/10.24018/ejfood.2022.4.5.564.

Hasan, S., S. Saha, M. S. I. Afrad, M. R. Islam, R. S. Sadi and M. T. R. Labib. 2023. Present status of pineapple cultivation in Bangladesh: Case of Madhupur Tract. *Turk. J. Agric.*

Food Sci. Technol. 11(8): 1304–1309. https://doi.org/10.24925/turjaf.v11i8.1304-1309.5891.

Helfand, S. M. and M. Taylor. 2018. The inverse relationship between farm size and productivity: Refocusing the debate. *Res. Pap. Econ*. 2018: 1–15. https://doi.org/10.1016/j.foodpol.2020.101977.

Hoque, M. A., M. S. H. Bhuiyan, M. Ahiduzzaman, S. Akhter and M. S. Hossain. 2023. Scenario of mango marketing by farmers in selected areas of Bangladesh. *Res. Rev. J. Crop Sci. Technol.* 12(1): 1–8. https://doi.org/10.37591/RRJoCST.

Hoque, M. Z., A. A. Mahmud, M. E. Haque, M. S. I. Afrad, M. F. Hossain, F. Yeasmin, F. A. Prodhan, M. S. Rahman, S. Hasan and S. Saha. 2023. Adoption of climate smart agricultural practices by charland farmers in Charfasson, *Bangladesh. J. Agric. Ecol. Res. Int.* 24(5): 87–97. https://doi.org/10.9734/JAERI/2023/v24i5545.

Houensou, D. A., G. G. Goudjo and M. M. Senou. 2021. Access to finance and difference in family farm productivity in Benin. *Sci. Afr*. 13: e00940. https://doi.org/10.1016/j.sciaf.2021.e00940.

Islam, T., S. Alam, M. Ahmed and M. Islam. 2019. Mango diseases diagnosis competency of farmers using colour disease images. *Measurement*. 31–38.

Jangid, R., A. Kumar, M. M. Masu, N. Kanade and D. Pant. 2023. Alternate bearing in fruit crops: Causes and control measures. *Asian J. Agric. Hortic. Res.* 10–19. https://doi.org/10.9734/ajahr/2023/v10i1217.

Javed, I. and K. Zahra. 2023. Impact of farmers' socioeconomic characteristics and technology adoption on agricultural income: Evidence from Central Punjab, Pakistan. *Int. J. Agric. Soc. Sci.* 3: 15–25. https://doi.org/10.70843/ijass.2023.03015.

Kalogiannidis, S. and D. Syndoukas. 2024. Impact of agricultural extension services on farm output: A worldwide viewpoint. *Res. World Agric. Econ*. 5(1): 1-12. https://doi.org/10.36956/rwae.v5i1.999.

Kochhar, S. 2011. Analysis of opportunities and challenges in intellectual property rights and agriculture in the Indian context. *In Global Challenges Report: Food Security and Intellectual Property*. pp. 62–93.

Kumar, A., B. D. Bhuj and C. P. Singh. 2021. Alternate bearing in fruit trees: A review. Int. J. Curr. Microbiol. *Appl. Sci*. 10(1): 1218–1235. https://doi.org/10.20546/ijcmas.2021.1001.146.

Kumar, N., D. P. Malik and R. Kumar. 2019. Economic analysis of mango (Mangifera indica L.) cultivation in Haryana. *Indian J. Econ. Dev*. 15(2): 282–288. https://doi.org/10.5958/2322-0430.2019.00034.9.

Mburu, J., M. A. Oyugi and P. M. Makenzi. 2023. Influence of access to extension

services on smallholder farmers' use of certified seed potatoes in Kenya. *Asian J. Agric. Ext. Econ. Sociol.* 41(4): 169–177. https://doi.org/10.9734/ajaees/2023/v41i41891.

Moahid, M., G. D. Khan, Y. Yoshida, N. P. Joshi and K. L. Maharjan. 2021. Agricultural credit and extension services: Does their synergy augment farmers' economic outcomes? *Sustainability*. 13(7): 3758. https://doi.org/10.3390/SU13073758.

Mondal, D. and S. Sen. 2023. Revisiting the debate on farm size and utilisation of agricultural land: Recent trends in India. *J. Asian Afr. Stud.* https://doi.org/10.1177/00219096231153147.

Novianty, A. and F. Awaliyah. 2022. Effect of land size on watermelon farm income in Tasikmalaya. *Mimbar Agribisnis*. 8(1): 424.

Ntabakirabose, G., J. C. Tuyisenge, P. Musoni, F. Ndaruhutse, J. C. N. Majuga, J. C. Izamuhaye, F. Hakizimana and J. O. Ogweno. 2021. Economic analysis of factors influencing avocado production and profitability in Rwanda. *Int. J. For. Bio-Res*. 7(6). https://doi.org/10.11648/j.ijfbr.20210706.14.

Okidim, I. A., C. C. Odukwo and V. N. Ozah. 2023. Socioeconomic determinants of modern agricultural technology adoption in Rivers State, Nigeria. *Int. J. Agric. Earth Sci.* 9(3): 1–14. https://doi.org/10.56201/ijaes.v9.no3.2023.pg1.14

Patel, S. G. and P. Patel. 2020. Relationship between profile of mango growers with level of awareness and adoption of value added techniques. *Int. J. Curr. Microbiol. Appl. Sci*. 9(1): 1392–1394. https://doi.org/10.20546/IJCMAS.2020.901.153.

Prasad, K., R. R. Sharma, S. Sethi and M. Srivastav. 2019. Influence of harvesting method on postharvest loss and quality of mango fruits. *Indian J. Agric. Sci.*, 89(3): 445–449.

Rahman, M. S. and M. Khatun. 2018. Adoption and farmers' perception of BARI Aam-3 mango variety in Bangladesh. *Res. Agric. Livest. Fish*. 5(3): 301–311.

Rahman, M. S., M. Khatun and M. M. Miah. 2019. Profitability analysis of mango cultivation and its impact on farmers' livelihood in Bangladesh. *Bangladesh J. Agric. Res.* 44(1): 139–152. https://doi.org/10.3329/BJAR.V44I1.40937.

Rahman, S. A., M. H. Imam, D. J. Snelder and T. Sunderland. 2012. Agroforestry for livelihood security in agrarian landscapes of Bangladesh. *Small-Scale For.* 11(4): 529–538. https://doi.org/10.1007/s11842-012-9198-y.

Raji, E., T. I. Ijomah and O. G. Eyieyien. 2024. Improving agricultural practices and productivity through extension services and innovative training programs. *Int. J. Appl. Res. Soc. Sci.* 6(7): 1297–1309. https://

doi.org/10.51594/ijarss.v6i7.1267.

Sabasi, D., C. R. Shumway and L. Kompaniyets. 2021. Analysis of credit access and US agricultural productivity. J. *Agric. Appl. Econ.* 53(3): 389–415. https://doi.org/10.1017/AAE.2021.17.

Sampa, A. Y., A. Alam, A. Latif and M. Islam. 2019. Socio-economic status and rationale of mango cultivation in Rajshahi district of Bangladesh. *Res. Agric. Livest. Fish*. 6(1): 79–90. https://doi.org/10.3329/RALF.V6I1.41389.

Shivran, J. S., M. L. Jat, R. K. Jat and A. Jat. 2020. Adoption of regular bearing in mango over biennial bearing. *Int. J. Curr. Microbiol. Appl. Sci.* 9(5): 149–154. https://doi.org/10.20546/IJCMAS.2020.905.016.

Singh, R. P. and R. C. Agrawal. 2019. Farmers' varieties in India and their legal protection. Indian *J. Agric. Sci.*, 89(9). https://doi.org/10.56093/ijas.v89i9.93450.

Singh, S. P. 2020. Financial viability and profitability of mango orcharding in Uttar Pradesh. *Econ. Aff.* 65(1). https://doi.org/10.30954/0424-2513.1.2020.11.

Solehudin, S. 2024. Influence of training on productivity of rice farmers in Subang. *Al Fikrah: J. Educ. Manag.* 12(1): 15. https://doi.org/10.31958/jaf.v12i1.8982.

Swain, S. C. 2014. Performance and profitability of mango based intercropping systems in Odisha. *Crop Weed*. 10(2). https://www.cropandweed.com/vol10issue2/pdf2005/29.pdf.

Teyung, P. and G. Luitel. 2023. Value chain analysis of mango production and distribution in Nepal. *Int. J. Appl. Sci. Biotechnol*. 11(4): 197–208. https://doi.org/10.3126/ijasbt.v11i4.60370.

Vasuki, R. and M. Soundariyan. 2022. Cost of cultivation and profitability of mango in Tamil Nadu. *EPRA Int. J. Agric. Rural Econ. Res*. 34–37. https://doi.org/10.36713/epra11806.

Vinodh, K., K. Mahendran and S. M. Lavanya. 2025. Consumer demand for exotic fruits in India. *Plant Sci. Today*. https://doi.org/10.14719/pst.6054.

Haq, A. Z. M. 2012. Farmers' education and farm productivity in Bangladesh. *Mediterr. J. Soc. Sci.*3(15): 108.

Zayed, K. 2022. Applying DPSIR framework on mango farming. *J. Environ. Eng. Stud*. 7(3): 10–17. https://doi.org/10.46610/joees.2022.v07i03.003.

Zegeye, M. B., A. H. Fikire and G. B. Meshesha. 2022. Determinants of multiple agricultural technology adoption in Ethiopia. *Cogent Econ. Finance*. 10(1). https://doi.org/10.1080/23322039.2022.2058189.