J Bangladesh Agril Univ 18(2): 388–394, 2020 https://doi.org/10.5455/JBAU.72568

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau

Economic evaluation of five years aged mango-based agroforestry practices established in the deforested land in the Madhupur Sal forest of Bangladesh

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ARTICLE INFO

Article history:
Received: 06 November 2019
Accepted: 26 March 2020
Published: 30 June 2020

Keywords:
Agroforestry,
Mango tree,
Cost of production,
BCR,
LER

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ABSTRACT

The study was carried out from July 2018 to June 2019 to analyze the economic profitability of mango-based agroforestry practices established in the deforested land in the Madhupur Sal forest. A sample of 5 years old established promising five Mango-based agroforestry practices viz. Mango-Pineapple-Ginger-Papaya-Banana-Turmeric, Mango-Pineapple-Ginger-Papaya-Banana, Mango-Turmeric-Papaya-Aroid, Mango-Lemon-Turmeric and Mango-Pineapple along with a non-agroforestry combination (except mango tree) for each of the respective practices having 0.12 ha plot area were selected through literature review, practical observation and consult with the community. A total of 100 farmers in which 10 for each of the respective combinations were selected for collecting required data. In order to evaluate the economic performances, data related to tree and crop parameters were collected from the respective plots as well as individual farmers in order to calculate the incurred cost, gross return, net profit, benefit-cost ratio (BCR) and land equivalent ratio (LER). The results revealed that the total calculated gross return (Tk/ha) and net profit (Tk/ha) for five years of the selected Mango-based agroforestry practices were 1076344, 956095, 816520, 443633, 253686 and 688925, 584723, 467892, 162817, 7998 respectively. While the total gross return (Tk/ha) and net profit (Tk/ha) for five years of the selected non-agroforestry combinations were 622886, 503430, 298289, 283782, 185968 and 356742, 248505, 89955, 89299, 5468 respectively. Among them the highest (1076344 Tk/ha and 688925 Tk/ha) gross return and net profit incurred for Mango-Pineapple-Ginger-Papaya-Banana-Turmeric based agroforestry practice than its non-agroforestry combinations (622886 Tk/ha and 356742 Tk/ha). The BCR and LER of the selected Mango-based agroforestry practices were 2.78, 2.57, 2.34, 1.57, 1.03 and 3.27, 2.76, 2.32, 1.93, 1.37 respectively which indicates that all the selected Mango-based agroforestry practices were profitable. Therefore, it can be concluded that the economic performance of mango-based agroforestry practice is more profitable than the sole cropping system.

Introduction

The Madhupur Sal forest is representing the major patches of Bangladesh Sal forests which are valuable in ecological as well as economic aspects that have been degraded due to destructive anthropogenic activities. About 50,000 forest dependant households including ethnic minorities are living in and around 21 villages of this forest area (Islam *et al.*, 2012, 2013, 2015). Moreover, two-third of the Madhupur forest areas (49748 ha) were deforested and subsequently encroached by the local people in order to practice commercial tree and/or crop cultivation (Muhammad *et al.*, 2008; Islam *et al.*, 2015). The local farmers of the Madhupur Sal forest rely on agroforestry practices that play a vital role offering multiple alternatives and opportunities with a view to improving farm production and income and also providing productive and protective functions to the ecosystems (Sharma *et al.*, 2007; Alam *et al.*, 2010; Kibria and Saha, 2011; Islam *et al.*, 2015). Researchers found different evidence that agroforestry practices increase farm income, conserve natural resources, generate environmental benefits, and are particularly well-suited to poor and female farmers (Franzel *et al.*, 2004; Kibria and Saha, 2011; Islam *et al.*, 2015). About 84% of the forest-dependent farmers at Madhupur Sal forest area generated cash income from selling agroforestry products and buying small cattle and other agricultural inputs (Islam *et al.,* 2012; Chakraborty *et al.*, 2015). Besides income, the agroforestry programs also supply fuelwood and fodder which ultimately boosts up the sustainable development of local people. These local agroforestry production systems have developed both in private and forest department encroached land and also differ from one another in terms of their economic and ecological performance as they have some benefits and drawbacks (Kibria and Saha, 2011). The majority of the local farmers do not

Cite this article

Hasan, M.K., Roshni, N.A., Hemel, S.A.K., Hossain, M.B. 2020. Economic evaluation of five years aged mango-based agroforestry practices established in the deforested land in the Madhupur Sal forest of Bangladesh. *Journal of Bangladesh Agricultural University*, 18(2): 388–394. https://doi.org/10.5455/JBAU.72568

have the scope to compare those potential agroforestry practices for further improvement with technological supports. Some researchers have already mentioned the benefits of banana, pineapple, lemon, turmeric, aroids, ginger, jackfruit and other seasonal crops cultivation along with agroforestry practices at the Madhupur Garh area (Gain, 2005; Safa, 2004; Hasan *et al.*, 2008; Alam *et al.*, 2010; Kibria and Saha, 2011; Islam *et al.,* 2012; Rahman *et al*., 2014). This has led to a demand for effective ways to analyze the economic performance of promising agroforestry practices providing benefits to farmers. Economic evaluation is the comparative analysis or evaluation of two or more interventions in terms of their cost and benefits (Sandesh, 2017). In this study economic evaluation means the potential benefits and costs are quantified, valued and compared over some period of time of these agroforestry practices.

Mango (*Mangifera indica* L.) is one of the most common and popular fruit and often acclaimed as the 'King of fruits' due to its excellent flavor, attractive color, delicious taste and high nutritive value (Purseglove, 1972; Sultana *et al.,* 2018). In Bangladesh, annual mango production is 1165804 metric ton occupying an area of 44366 hectares of land (BBS, 2018). The plant starts bearing 3 to 5 years after planting and reaches its maximum bearing capacity within 12-15 years (Khatun, 2015). According to past research evidence, productivity analysis of jackfruit, lemon, pineapple and banana-based agroforestry systems practiced in private or participatory programs in the Madhupur tract revealed that the agroforestry practice to be beneficial in terms of benefit-cost ratio analysis (Hasan *et al*., 2008; Kibria and Saha, 2011). The socio-economic importance of mango-based agroforestry in Chapainawabgong district also introduced a profitable window for cultivating crops in association with mango (Khatun, 2015). Intercropping crops with mango not only increase the overall productivity of land but also modifies the low productive environment and increases the availability of nutrients (Tiwari and Baghel, 2014). The research related to productivity evaluation of farmer led mango-based agroforestry practices in the study area was negligible that leads to measure the economic analysis of mango-based agroforestry practices established in the deforested land of Madhupur Sal forest area. Therefore, considering the aforementioned facts, it is necessary to analyze the economic evaluation of this promising mango-based agroforestry practices in order to calculate farm income, benefit-cost ratio and land equivalent ratio to maximize farm productivity maintaining sustainable development at Madhupur Sal forest of Bangladesh.

Methodology

Selection of the study area

The majority of the Bangladesh Sal forests are situated in the central part of the country, which consists of the Dhaka, Mymensingh, Tangail, and Gazipur districts (Islam and Sato, 2012; Islam *et al.*, 2015; Alam *et al.*, 2008). The present study is located at the Madhupur Sal Forest, which is situated in the districts of Tangail and Mymensingh, along with almost 46% of the other Bangladesh Sal forests (Islam and Sato, 2012; Muhammed *et al.*, 2008) (Fig. 1). Geographically, it is located at 23°50′ to 24°50′ north latitude and 89°54′ to 90°50′ east longitudes (Fig. 1). The total area of Madhupur Sal forest is about 18447.44 ha comprising four ranges namely Madhupur National Park, Dokhla, Arunkhola and Madhupur (Rahman *et al.,* 2013). Four villages viz. East Gaira, west Gaira, Jolai and Magontinagar of Madhupur Sal forest were selected for the study area because mango-based agroforestry systems are dominant in this area (Fig. 1).

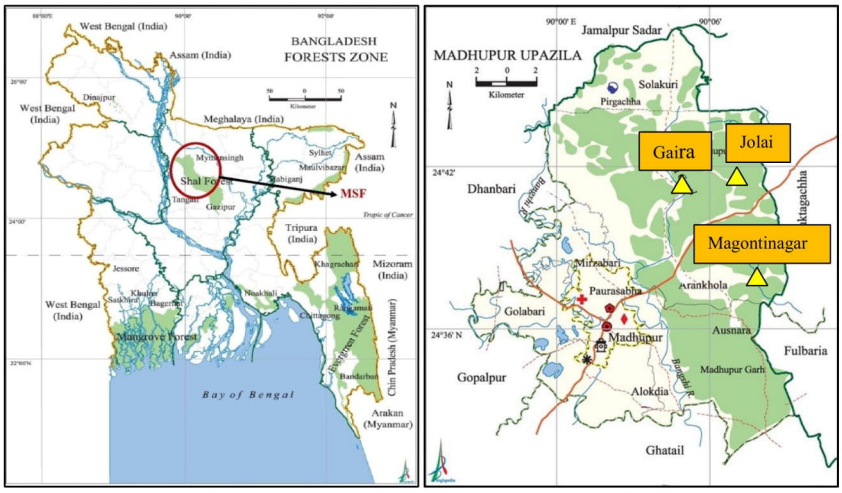

Fig. 1. (A) Bangladesh forest map showing Madhupur Sal Forest (MSF) (Source: Banglapedia), and (B) Madhupur Upazila of Tangail district representing the study locations (Banglapedia)

Economic evaluation of mango-based agroforestry

Sampling design

The study dealt with five different mango tree-based agroforestry practices having a 0.12 ha area for each sample plot along with a non-agroforestry plot (except tree) for each combination. The total numbers of plots were 10 of which 5 for mango-based agroforestry practices and rest 5 for non-agroforestry practices. Due to time limitations, the study selected both established mango-based agroforestry and non-agroforestry practices in the study area (Table 1).

Table 1. Distribution of sample plots and respondents

	Composition	No. of farmers
Agroforestry combination	Mango-Pineapple-Ginger-Papaya-Banana-Turmeric	10
	Mango-Pineapple-Ginger-Papaya-Banana	10
	Mango-Turmeric-Papaya-Aroid	10
	Mango-Lemon-Turmeric	10
	Mango-Pineapple	10
	Pineapple-Ginger-Papaya-Banana-Turmeric	10
Non-agroforestry combination	Pineapple-Ginger-Papaya-Banana	10
	Turmeric-Papaya-Aroid	10
	Lemon-Turmeric	10
	Pineapple	10
	Total	**100**

Selection of mango-based agroforestry

Through secondary data, practical observation and consult with the community the following five mango-based agroforestry practices along with a non-agroforestry, as well as 10 farmers in a total 100 for each of the respective combinations were selected in the study area (Table 1).

Data collection

From the selected plots and farmers, various tree-crop parameters were collected through practical observations, questionnaire surveys, interview with key informants, and focus group discussion in accordance with the requirement of the study.

Collection of crop data

In order to calculate crop produce, following parameters were collected from the farmer's plot and respondents- number of fruits/plant, weight of fruits/plant (kg), fruit price (Tk/kg), crop price (Tk/kg), cost of production (Tk/ha), income (Tk/ha) and crop yield (Tk/ha).

Collection of tree data

The Productivity of tree components was measured by collecting the following parameters- number of mango trees/plot, number of fruits/tree, weight of fruits/tree (kg), fruit price (Tk/kg), cost of production (Tk/ha), income (Tk/ha) and tree yield (Tk/ha).

Profitability analysis

In order to perform an economic evaluation of selected mango-based agroforestry practices, investment analysis was carried out considering the timing of benefit and cost during the study period.

Determination of total cost of production

The total cost of production was estimated by using the following formula:

TC = Input cost + Overhead cost

Where TC =Total Costs of Production

Determination of total income

The total income of the individual agroforestry practices was computed by adding crop income and tree income.
Total income = Crop income + Income from tree products

Determination of net profit

Net profits were estimated by using the following formula:

NP = TI- TC

Where, NP = Net Profits; TI = Total Income; TC = Total Cost

Calculation of Benefit-Cost Ratio (BCR)

The benefit-cost ratio was estimated according to Muhammed *et al.* (2008):

$$\text{Benefit-Cost Ratio (BCR)} = \frac{\sum_{t=1}^{n} \frac{Bn}{(1+r)^n}}{\sum_{t=1}^{n} \frac{Cn}{(1+r)^n}}$$

Where, B_n= Gross benefit in the i^{th} year, C_n= Total cost in an i^{th} year, t = Number of years (1, 2, 3…n). The BCR greater than 1 indicates that the land-use system is profitable.

Calculation of Land Equivalent Ratio (LER)

LER is the ratio between the relative yield of each tree and crop species in an agroforestry system in comparison to the yield of the same tree and crop species in a monoculture over the same period (Mead and Wiley, 1980). In agroforestry situations, it is calculated as follows:

$LER = C_i/C_s + T_i/T_s$

Where, C_i = crop yield under intercropping; C_s = crop yield under sole cropping; T_i = tree yield under intercropping, and T_s = tree yield under sole cropping.

While LER1 $\leq$ 1 means that there is no productivity advantage of agroforestry over monoculture, a LER1 > 1 suggests that the production in the agroforestry system is higher than the one in a monoculture system.

Statistical analysis

The collected data about the cost of production, yield and income of crops and trees from agroforestry and

non-agroforestry plots were organized, compiled and note down in a Microsoft Office word document pages. Then the data were analyzed using the computer programme Microsoft Office Excel and SPSS version 25.0 for computing mean, graphs, etc.

Results and Discussion

Economic analysis of mango-based AFP

Mango-Pineapple-Ginger-Papaya-Banana-Turmeric based AFP

The result showed that the incurred cost of production of 1st, 2nd, 3rd, 4th and 5th year was BDT 135057, 71433, 63450, 59934, 57545 respectively, where the initial cost of establishment of Mango-Pineapple-Ginger-Papaya-Banana-Turmeric based agroforestry practice was the highest which was gradually reduced towards 5th year of production (Table 2). According to the result, the gross return of 1st, 2nd, 3rd, 4th and 5th year was BDT 141553, 291942, 267719, 163648, 211482 respectively (Table 2). The net profit of 1st, 2nd, 3rd, 4th and 5th year were BDT 6496, 220509, 204269, 103714, 153937 respectively where initially lower profit obtained because of no return of mango production (Table 2). After that, net profit was increased gradually up to 3rd years of cultivation due to the maximum combined return of this mango-based agroforestry practice. Although mango started production from the 3rd year of cultivation net profit of 4th and 5th year was reduced due to alternate bearing habit of mango. The result determined that Benefit-Cost Ratio (BCR) and Land Equivalent Ratio (LER) was 2.78 and 3.27 which clearly indicated that this agroforestry practice was profitable with respect to economic productivity (Table 2). Rahman *et al.* (2018) assessed the productivity and profitability of jackfruit-eggplant based agroforestry in terrace ecosystem at Narsingdi district of Bangladesh and found that the gross return, net return (NR) and BCR of Jackfruit-Eggplant agroforestry system were BDT 714558, BDT 557863 and 4.56 respectively which were 45, 66, and 45% higher than their sole cropping systems. Khatun (2015) found that discounted benefit-cost ratio (2.006), and the internal rate of return (29%) in case of agro-economic performance of mango-based agroforestry system which clearly indicated that mango-based agroforestry system was productive and economically profitable.

Table 2. Profitability analysis of Mango-Pineapple-Ginger-Papaya-Banana-Turmeric based AFP

Year	Cost of production (Tk/ha)	Gross Return (Tk/ha)	Net Profit (Tk/ha)	BCR	LER
1	135057	141553	6496		
2	71433	291942	220509		
3	63450	267719	204269	2.78	3.27
4	59934	163648	103714		
5	57545	211482	153937		
Total	387419	1076344	688925		

Mango-Pineapple-Ginger-Papaya-Banana based AFP

From the result, the incurred cost of production of 1st, 2nd, 3rd, 4th and 5th year of Mango-Pineapple-Ginger-Papaya-Banana based agroforestry was Tk.101508, 78262, 81962, 65520, 44120 respectively (Table 3). The income analysis of this agroforestry practice revealed that the gross return of 1st, 2nd, 3rd, 4th and 5th year was BDT 399408, 205186, 162825, 74322, 114354 respectively (Table 3). The net profit of 1st year (BDT 297900) was the highest due to the maximum production of banana, papaya, ginger of this practice. The net profit of the 2nd year was BDT 1269242 which came from the maximum production of pineapple of this agroforestry practice. Due to the alternate bearing habit of mango tree net profit of the 4th year of production was not remarkable compared to the previous year. The Benefit-Cost Ratio (BCR) and Land Equivalent Ratio (LER) of this agroforestry practice were 2.57 and 2.75 (Table 3) which more than 1 indicated that this practice is profitable in terms of economic productivity. Rahman *et al.* (2017) found similar findings in the case of fruit tree-based agroforestry systems which clearly indicated that combined production of the sweet gourd with mango, guava, jujube and lemon was profitable than sole cropping. Miah (2014) conducted a research in Khulna, Bangladesh on profitability analysis of Mango-Transplant Aman rice-based agroforestry systems and found that the net income was 450000 BDT/ha/year. He included vegetable with existing combination and gets net income 620500 BDT/ha/year which was 38% higher than the existing mango-based agroforestry combination. Hanif *et al.* (2010) depicted that Litchi based agroforestry system ensures a higher economic return and more sustainable than sole cropping.

Table 3. Profitability analysis of Mango-Pineapple-Ginger-Papaya-Banana based AFP

Year	Cost of production (Tk/ha)	Gross Return (Tk/ha)	Net Profit (Tk/ha)	BCR	LER
1	101508	399408	297900		
2	78262	205186	126924		
3	81962	162825	80863	2.57	2.75
4	65520	74322	8802		
5	44120	114354	70234		
Total	371372	956095	584723		

Mango-Turmeric-Papaya-Aroid based AFP

From the result, it has been observed that the cost of production of Mango-Turmeric-Papaya-Aroid based agroforestry practice of 1st, 2nd, 3rd, 4th and 5th year was BDT 101970, 75692, 61730, 60373, 48863 respectively where the initial cost of establishment of this agroforestry practice was the highest (Table 4). The gross return of 1st, 2nd, 3rd, 4th and 5th year was BDT 60029, 42648, 326007, 282970 and 104866 respectively (Table 4). The profit was not found from the 1st and 2nd year of production due to initially high establishment cost and no gross return from mango production while 3rd year of production remarkable because mango started production from that time (Table 4). The Benefit-Cost

Ratio (BCR) and Land Equivalent Ratio (LER) of the Mango-Turmeric-Papaya-Aroid based agroforestry system were 2.34 and 2.32 (Table 4) that represented positive results in terms of economic profitability because obtained LER and BCR were more than 1. So, the Mango-Turmeric-Papaya-Aroid based agroforestry system was profitable. Similar observations were also recorded by Miah (2014) in his study on profitability analysis of new agroforestry system Mango-Transplant Aman rice-Vegetable over existing agroforestry combination Mango-Transplant Aman rice in Khulna, Bangladesh. The result showed that the net income of existing agroforestry systems was 450000 BDT/ha/year and the new agroforestry systems were 620500 BDT/ha/year which was 38% higher than the existing mango-based agroforestry combination. Hasan *et al.* (2008) carried out a study in the Madhupur tract of Gazipur district and the result revealed that the total production of a jackfruit-pineapple based agroforestry system is higher and more profitable than its sole cropping.

Table 4. Profitability analysis of Mango-Turmeric-Papaya-Aroid based AFP

Year	Cost of production (Tk/ha)	Gross Return (Tk/ha)	Net Profit (Tk/ha)	BCR	LER
1	101970	60029	No profit		
2	75692	42648	No profit		
3	61730	326007	264277	2.34	2.32
4	60373	282970	222597		
5	48863	104866	56003		
Total	348628	816520	467892		

Mango-Lemon-Turmeric based AFP

The result presented that the total cost of production of Mango-Lemon-Turmeric based agroforestry practice of 1st, 2nd, 3rd, 4th and 5th year was BDT 99711, 52921, 49098, 40033, 39053 respectively (Table 5). The incurred production cost was the highest at the initial 1st and 2nd year of BDT 99711 and 52921 due to the purchasing of planting materials, fertilizers, mulch and cost of labor. According to the result, the gross return of 1st, 2nd, 3rd, 4th, 5th year of Mango-Lemon-Turmeric based agroforestry practice was BDT 14267, 91265, 124578, 119297, 94226 respectively (Table 5). According to profitability analysis, profit was not found from the 1st year of production due to higher investment costs of mango than gross return (Table 5). The net profit of the 3rd and 4th years of production was significant because mango started full production at that time. The result showed that Benefit-Cost Ratio (BCR) and Land Equivalent Ratio (LER) were 1.57 and 1.93 (Table 5) which were more than 1 indicated that Mango-Lemon-Turmeric based agroforestry system is profitable in terms of productivity. Similar results were observed by Rawat *et al*. (2002) for the *Dendrocalamus strictus* plantation in North India. Another study by Chakraborty *et al*. (2015), reported that farmers practicing agroforestry better off than those not practicing agroforestry, both socially and economically.

Mango-Pineapple based AFP

The result of profitability analysis of yearly basis showed that the cost of production of the Mango-Pineapple based agroforestry system of 1st, 2nd, 3rd, 4th and 5th year was BDT 66257, 44429, 42753, 50396, 41853 respectively (Table 6). Among the results, the cost of production for the 1st year was the highest of Tk. 66257 which reduced gradually reduced towards 5th year production. The observed results showed that the gross return of 2nd, 3rd, 4th and 5th year of Mango-Pineapple based agroforestry practice was BDT 45863, 103681, 37557 and 66585 respectively (Table 6). In this practice at 1st year, no return obtained because pineapple started production from 2nd year and mango started from 3rd year of production in this practice (Table 6). So profit was not found at 1st year of mango production. On the other hand, due to alternate bearing habit of mango and no return of pineapple production profit were not also obtained at 4th year of production in this practice. The result revealed that the Benefit-Cost Ratio (BCR) and Land Equivalent Ratio (LER) was 1.03 and 1.37 (Table 6) indicated that Mango-Pineapple based agroforestry practice was profitable. Khatun (2015) found that discounted benefit-cost ratio (2.006), and the internal rate of return (29%) in case of agro-economic performance of mango-based agroforestry system which clearly indicated that mango-based agroforestry system was productive and economically profitable. Miah (2014) included Malta, Papaya, and Brinjal in Jackfruit orchard at Narsingdi district of Bangladesh and found that the net income of Jackfruit-Malta-Papaya-Brinjal based agroforestry was 121500 BDT/ha/year which was 159% higher than the net income (47000 BDT/ha/year) of sole Jackfruit orchard. Jha and Lalnuntluanga (2004) reported that similar results in the case of intercropping of soya bean with *Melocanna baccifera* and *Dendrocalamus longispathus*.

Table 5. Profitability analysis of Mango-Lemon-Turmeric based AFP

Year	Cost of production (Tk/ha)	Gross Return (Tk/ha)	Net Profit (Tk/ha)	BCR	LER
1	99711	14267	No profit		
2	52921	91265	38344	1.57	
3	49098	124578	75480		1.93
4	40033	119297	79264		
5	39053	94226	55173		
Total	280816	443633	162817		

Table 6. Profitability analysis of Mango-Pineapple based AFP

Year	Cost of production (Tk/ha)	Gross Return (Tk/ha)	Net Profit (Tk/ha)	BCR	LER
1	66257	0	No profit		
2	44429	45863	1434		
3	42753	103681	60928	1.03	1.37
4	50396	37557	No profit		
5	41853	66585	24732		
Total	245688	253686	7998		

Comparison of economic profitability of selected mango-based agroforestry practices versus non- AFP

From the result, it showed the total gross return and net profit of Mango-Pineapple-Ginger-Papaya-Banana, Mango-Turmeric-Papaya-Aroid, Mango-Lemon-Turmeric, Mango-Pineapple based agroforestry practices was BDT 1076344, 956095, 816520, 443633, 253686 respectively and BDT 688925, 584723, 467892, 162817, 7998 respectively (Table 7). The total gross return and net profit of non-agroforestry practices (except mango tree) were BDT 622886, 503430, 298289, 283782, 185968 and BDT 356742, 248505, 89955, 89299, 5468 respectively (Table 7). According to the above-mentioned results, it showed that the total gross return and net profit of mango-based agroforestry practices was higher than sole cropping (except mango tree) which means non-agroforestry practices (Table 7) because superior income was obtained when crops cultivation is associated with mango than sole cropping. The BCR and LER of Mango-Pineapple-Ginger-Papaya-Banana-Turmeric, Mango-Pineapple-Ginger-Papaya-Banana, Mango-Turmeric-Papaya-Aroid, Mango-Lemon-Turmeric, Mango-Pineapple based agroforestry practices were 2.78, 2.57, 2.34, 1.57, 1.03 and 3.27, 2.76, 2.32, 1.93, 1.37 respectively (Table 7) which revealed that maximum profits were earned from maximum combinations of components. According to the benefits cost analysis, it has been found that Mango-Pineapple-Ginger-Papaya-Banana-Turmeric based agroforestry was most profitable having BCR of 2.78 followed by Mango-Pineapple-Ginger-Papaya-Banana>Mango-Turmeric-Papaya-Aroid>Mango-Lemon-Turmeric> Mango-Pineapple based agroforestry practices (Table 7). Bari *et al.* (2016) reported that maximum BCR (5.20) was found in the Litchi based agroforestry systems over sole cropping (BCR=4.38). The highest benefit-cost ratio (3.54) was recorded from coconut+guava based multistoried agroforestry which was higher than their sole cropping (1.65) observed by Bari and Rahim (2012). The Calculate Net Present Value (NPV) and Benefit-Cost Ration (BCR) of the pineapple plantation were BDT 487010.79 and 5.35 respectively at 10% interest rate which indicated the maximum profitability of Pineapple agroforestry practice in Madhupur Sal forest that reported by Rana (2010). Dwivedi *et al.* (2007) found that B: C ratio (3.00) that was higher for poplar based agrisilviculture than poplar (2.84) and eucalyptus (2.68) based bund system.

Table 7. Comparison of economic profitability of Mango-based AFP vs. Non–Agroforestry (NAF) practice

Cropping systems		Gross Return (Tk/ha)	Net Profit (Tk/ha)	BCR	LER
Mango-Pineapple-Ginger-Papaya-Banana-Turmeric	Agroforestry	1076344	688925	2.78	3.27
	NAF	622886	356742	2.34	
Mango-Pineapple-Ginger-Papaya-Banana	Agroforestry	956095	584723	2.57	2.76
	NAF	503430	248505	1.97	
Mango-Turmeric-Papaya-Aroid	Agroforestry	816520	467892	2.34	2.32
	NAF	298289	89955	1.43	
Mango-Lemon-Turmeric	Agroforestry	443633	162817	1.57	1.93
	NAF	283782	89299	1.45	
Mango-Pineapple	Agroforestry	253686	7998	1.03	1.37
	NAF	185968	5468	1.01	

NAF=Non–Agroforestry

Conclusion

From a financial point of view, the Mango-Pineapple-Ginger-Papaya-Banana-Turmeric based agroforestry is much more suitable than the other agroforestry practices in respect of BCR and LER which can be increased eventually by proper maintenance of the practice. All the selected mango-based agroforestry practices are more profitable than their non-agroforestry systems in terms of economic performances. The agroforestry systems are more profitable than the cultivation of sole cropping. The amount of components available in the system has a direct effect on productivity as well as the presence of mango also increases the overall yield of respective mango-based agroforestry systems.

Acknowledgments

This research work was funded by the Ministry of Science and Technology (MoST), Government of the People's Republic of Bangladesh, under Special Allocation for Science and Technology.

References

Alam, M., Furukawa, Y. and Harada, K. 2010. Agroforestry is a sustainable land-use option in degraded tropical forests: a study from Bangladesh. *Environment Development and Sustainability*, 12: 147–158. https://doi.org/10.1007/s10668-009-9186-3

Alam, M.; Furukawa, Y.; Sarker, S.K. and Ahmed, R. 2008. Sustainability of Sal (*Shorea robusta*) forest in Bangladesh: Past, present and future actions. International *Forestry Review*, 10: 29–37. https://doi.org/10.1505/ifor.10.1.29

BBS (Bangladesh Bureau of Statistics) 2018. Statistical Year Book of Bangladesh. Statistics Division, Ministry of Planning, Bangladesh Secretariat, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. pp. 159-160.

Bari, M. S. and Rahim, M. A. 2012. Economic evaluation and yield performance of some medicinal plants in coconut-based multistoried agroforestry systems. *The Agriculturists*, 10(1): 71-80. https://doi.org/10.3329/agric.v10i1.11067

Bari, M. S., Zaman, M. R., Kajal, M. and Firoz, H. M. 2016. Potentiality of Litchi-Fodder Based Agroforestry System in Bangladesh. *Journal of Food and Nutrition Research*, 4(2):76-81.

Chakraborty, M., Haider, M. Z. and Rahaman, M. M. 2015. Socio-economic impact of cropland agroforestry: evidence from

Jessore district of Bangladesh. *International Journal of Research in Agriculture and Forestry*, 2(1):11-20.

Dwivedi, R. P., Kareemulla, K., Singh, R., Rizvi, R. H. and Chauhan, J. 2007. Socio-economic analysis of agroforestry systems in Western Uttar Pradesh. *Indian Research Journal of Extension Education,* 7(2&3): 18-22.

Franzel, S., Denning, G. L., Lilleso, J. P. B. and Mercado, A. R. 2004. Scaling up the impact of Agroforestry: Lessons from three sites in Africa and Asia. *Agroforestry Systems*, 61(1-3):329-344. https://doi.org/10.1023/B:AGFO.0000029008.71743.2d

Gain, P. 2005 (Ed.). The last forests of Bangladesh. Society for Environment and Human Development (SEHD), Dhaka, Bangladesh. Available at: https://www.sehd.org/publications/environment/14-last-forests-of-bangladesh

Hasan, M. K., Ahmed, M. M. and Miah, M. G. 2008. Agro economic performance of the jackfruit-pineapple agroforestry system in Madhupur Tract. *Journal of Agriculture and Rural Development*, 6(1): 147-156. https://doi.org/10.3329/jard.v6i1.1672

Hanif, M. A., Amin, M. H. A., Bari, M. S., Ali, M. S. and Uddin, M. N., 2010. Performance of okra under litchi based agroforestry system. *Journal of Agroforestry and Environment*, 4(2): 137-139.

Islam, K. K., Jose, S., Tani, M., Hyakumura, K., Krott, M. and Sato, N. 2015. Does actor power impede outcomes in the participatory agroforestry approach? Evidence from the Sal forests area, Bangladesh. *Agroforestry Systems*, 89:885–899. https://doi.org/10.1007/s10457-015-9822-x

Islam, K. K., Rahman, G. M. M., Fujiwara, T. and Sato, N. 2013. People's participation in forest conservation and livelihoods improvement: experience from a forestry project in Bangladesh. *International Journal of Biodiversity Science, Ecosystem Services and Management*, 9(1):30-43. https://doi.org/10.1080/21513732.2012.748692

Islam, K. K., Ullah, M.O., Hoogstra, M. and Sato, N. 2012. Economic contribution of participatory Agroforestry program to poverty alleviation: a case from Sal forests, Bangladesh. *Journal of Forestry Research*, 23(2): 323-332. https://doi.org/10.1007/s11676-012-0260-6

Islam, K.K. and Sato, N. 2012. Participatory forestry in Bangladesh: Has it helped to increase the livelihoods of Sal forests dependent people. *Southern Forest*, 74: 89-101. https://doi.org/10.2989/20702620.2012.701434

Jha, L. K. and Lalnuntluanga, M. C. 2004. Study on growth performance of bamboo species of *Melocanna baccifera* and *Dendrocalamus longispathus* along with crop (*Glycine max*) in degraded jhum land of Mizoram. *Indian Forester*, 130(9):1071-1077

Khatun, M. A. 2015. Study on agro-economic performance of mango-based agroforestry system at Shibgonj Upazila under Chapainawabgonj district. M.S. Thesis, Department of Agroforestry and Environmental Science, Sher-E-Bangla Agricultural University, Dhaka, Bangladesh.

Kibria, M. G. and Saha, N. 2011. Analysis of existing agroforestry practices in Madhupur Sal forests: an assessment based on ecological and economic perspectives. *Journal of Forestry Research*, 22(4):533-542. Available at: https://doi.org/10.1007/s11676-011-0196-2

Mead, R. and Willey, R. W.1980. The concept of a "Land Equivalent Ratio" and advantages in yields from intercropping. Experimental Agriculture, 16: 217–228. https://doi.org/10.1017/S0014479700010978

Miah, M. G. 2014. Improvement of Agroforestry Practices for Better Livelihood and Environment: BSMRAU Component. Coordinated Sub-Project. BARC, Farmgate, Dhaka-1215.

Muhammad, N., Koike, M., Haque, F. and Miah, M. D. 2008. Quantitative assessment of people-oriented forestry in Bangladesh: A case study from Tangail Forest Division. *Journal of Environmental Management,* 88(1): 83-92. https://doi.org/10.1016/j.jenvman.2007.01.029

Perseglove, J. W. 1972. Tropical Crops: Monocotyledons. Halsted Press Division, Wiley. London.chnique, 23: 807-819.

Rahman, A., Rahman, M. A., Miah, M. G., Hoque, A. and Rahman, M. 2018. Productivity and profitability of jackfruit-eggplant agroforestry system in the terrace ecosystem of Bangladesh. *Turkish Journal of Agriculture. Food Science and Technology*, 6(2): 124-129. https://doi.org/10.24925/turjaf.v6i2.124-129.1330

Rahman, G. M. M., Rana, S., Wadud, M. A., Khatun, M. A. and Mahboob, M. G. 2017. Performance of sweet gourd under fruit tree-based agroforestry practices in char land ecosystem. *Journal of Agroforestry and Environment*, 11(1 & 2): 165-170

Rahman, G. M. M., Wadud, M. A., Shahjahan, M. and Jewel, K. N. A. 2014. Fruit tree-based agroforestry practices in Charland farming system. *Journal of Agroforestry and Environment*, 8(1): 1-6.

Rahman, M. A., Bodiuzzaman, M., Miah, M. A., Hossain, M. N., Rokanuzzaman M., 2013. Causes of Deforestation and Conservation of Madhupur Sal Forest in the Tangail Region. *Journal of Environmental Science and Natural Resources*, 6(2): 109-114. https://doi.org/10.3329/jesnr.v6i2.22105

Rana, M. P. 2010. Pineapple agroforestry practice in Madhupur Sal (*Shorea robusta*) forest: a sustainable way to forest conservation and livelihood security. International Conference on Forestry Education and Research for the Asia Pacific Region, College, Laguna, Philippines, 23-25 November 2010, pp. 75-76.

Rawat, J. S., Singh, T. P. and Rawat, R. B. S. 2002. Potential of bamboos in agroforestry in India. In: National Workshop on Policy and Legal Issues in Cultivation and Utilization of Bamboo, Rattan and Forest Trees on Private and Community Lands, Kerala, 7-9 August 2001. Proceedings, Peechi, KFRI, pp.38-44.

Safa, M. S. 2004. The effect of participatory forest management on the livelihood of the settlers in a rehabilitation program of degraded forest in Bangladesh. *Small-scale Forest Economics, Management and Policy*, 3(2):223-238. https://doi.org/10.1007/s11842-004-0016-z

Sandesh, A. 2017. Public Health Notes; Economic Evaluation, Types of economic evaluation**.** Available at: https://www.publichealthnotes.com › economic-evaluation-types

Sultana, A., Chowdhury, M. F., Pervez, A. K. M. K. 2018. Present status of mango cultivation in Bangladesh: the case of Shibgonj Upazilla of Chapainawabgonj district. *Journal of Agricultural and Rural Research,* 2(3): 47-55.

Sharma, R., Xu, J. and Sharma, G. 2007. Traditional Agroforestry in the eastern Himalayan region: Land management system supporting ecosystem services. *Tropical Ecology*, 48(2):189-200.

Tiwari, R. and Baghel, B. S. 2014. Effect of intercropping on plant and soil of Dashehari mango orchard under low productive environments. *The Asian Journal of Horticulture*, 9(2):439-442. https://doi.org/10.15740/HAS/TAJH/9.2/439-442