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Agroforestry as an Ecofriendly Pathway to Income Generation and Livelihood Improvement: The Case of the Madhupur Garh, Bangladesh

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Abstract: Agroforestry production systems are underappreciated for their role in meeting the SDGs on poverty, food security, and climate change. In Bangladesh, low-productive agroforestry practices also provide ecosystem services and supply food to more than 22 million poor families. Accordingly, Madhupur Garh's agroforestry practices are very promising and act as a significant factor in providing several outputs and opportunities for over 50,000 farmers to improve farm productivity, livelihoods, and resource conservation. Therefore, a case study was undertaken to analyze the economical profitability of promising local agroforestry practices and their impacts on the livelihoods of the rural farmers living in Madhupur Garh. This study identified six of the most common potential agroforestry practices in the Madhupur Garh. Among six identified agroforestry practices, the highest gross return and net profit were obtained from the Acacia-Pineapple-Ginger-based agroforestry practice (BCR 2.83). Moreover, these agroforestry models have simultaneously improved participants' social, physical, human, and ecological capital. So, the study argues that these agroforestry models not only provide economic returns but also augment the livelihood capital of the local farmers, thus developing their community as a whole, and this research looks at some of the key aspects of that development. Therefore, it can be concluded that the Acacia-Pineapple-Ginger-based agroforestry program can be the most effective strategy for generating income for the rural people in the study area and have an impact on the local farmers' livelihoods in the Madhupur Garh of Bangladesh.

Keywords: Agroforestry; Livelihood; Benefit-Cost; Income.

INTRODUCTION

The constant depreciation of natural resources, particularly forest and land, has turned into a major issue because these countries' large populations rely heavily on these natural resources for outliving (FAO 1999). Deforestation is a significant cause of occurring soil erosion and land degradation (Barbier 1998). Agroforestry, a land utilization system characterized by the cultivation of several tree species in association with crops, is a good land use strategy for depleting lands. It aids in the prevention of soil erosion, the reversal of environmental deterioration with the help of biological interactions between trees and field crops, as well as the improvement of agricultural revenue (Sanchez 1994; Garity 2004). Being a land-utilization system, agroforestry has been citable considered a sustainable and cheaper method as it helps to mitigate the degradation process associated with the cultivation of land and its' retention in the ecosystem (Vergara and Nicomedes 1987). This practice is recognized widely as an applied science that is instrumental in ensuring food security, poverty alleviation, and promoting ecosystem resilience at the scale of thousands of smallholder farmers belonging in the tropical region (Sharma et al. 2007). Income generation from agroforestry practices was given lesser priority among farmers in the past because of the ampleness of both timber and non-wood products. Almost all the outputs were used for consumption (e.g., household usage and selling to other farmers if required) as farmers considered that there was lesser market value for such outputs. However, as natural forest resources are used up, there is low availability of wood and non-wood produces. Resulting from this, the value of agroforestry practices is rising in the market.

An agroforestry practice enhances the livelihood circumstances of participants by enhancing profitability, sustainability, and security through balanced soil usage and

fertility maintenance. It becomes a consistent source of revenue. If their crops fail, farmers may be able to earn money from trees. As a result, it poses no risk to farmers. It can also give immediate agricultural advantages while waiting for long-term tree benefits. On a long-term basis, agroforestry may provide a strong ecological foundation for higher agricultural and animal output, more predictable economic returns, and a wider range of social advantages. This is an urgent need for income, nutrition, health and reduction of economic risk, and improvement of household food security (Baumann and Sinha 2001). At present, the forest area is dominated by cropland for agroforestry, aftereffect to a land-use confrontment between agriculture and forestry in Bangladesh. It is important to explore a suitable alternative to overcome this situation. Because neither forest land nor sole grain cropland can be expanded, the country must establish a mixed production method that integrates trees and crops, which is today known as agroforestry. According to Islam et al. (2012), agroforestry in the Madhupur Sal forest improved local poor people's livelihoods and alleviated poverty. Islam and Sato (2012) hypothesized that the government of Bangladesh's forest management initiatives may enhance the livelihoods of impoverished forest-dependent people. Several other researchers conducted several studies on agroforestry systems, which demonstrated an improvement in the livelihoods of participating farmers in various areas around Bangladesh (Chowdhury and Satter 1993; Khan et al. 2007; Salam et al. 2005; Safa 2004; Islam et al. 2013, 2015).

On the contrary, there was no major research to determine the influence of agroforestry, particularly woodlot and agroforestry, on local people's livelihoods in Bangladesh's Madhupur Sal forest, which prompted the study to proceed to the specific location. As a result, it is predicted that this study will be able to provide important information on the existing agroforestry practices, and their influence on rural people's current livelihood situation. Furthermore, changes in livelihood as a result of the influence of agroforestry are another problem in Bangladesh due to the scarcity of relevant data and prior research. Therefore, the study objectives were to investigate different local agroforestry practices based on their productivity and income generation and evaluate their impact on the farmers' livelihoods in the Madhupur Garh.

MATERIALS AND METHODS

Area of Study: The study was initiated in Solakuri, Joynagacha, Bhutia, Dakhla, Auronkhola, Gaira, Makontinagar, and Beribaid, 8 villages under the Madhupur Garh (Figure 1). The soils of the areas are extremely oxidized in nature, reddish-brown clay with moderate to strongly acidic. The soils are categorized by low organic matter content and less fertile (Alam 1995; Islam and Hyakumura 2019; Islam et al. 2021). The annual rainfall of the Madhupur region lies between 203-229 cm and the annual temperature lies between 10-34◦C. The humidity of the region ranges from 60-86% (Hasan et al. 2016).

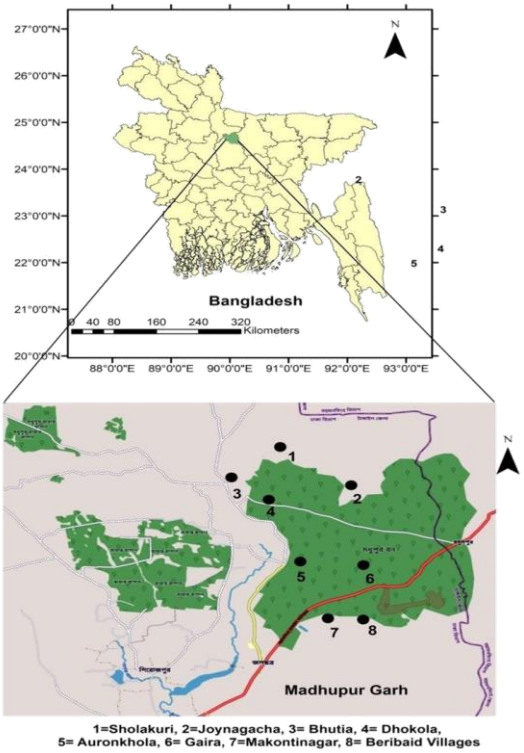

Figure 1. Study area showing Bangladesh and Madhupur Garh.

Description of the Agroforestry Practices: Madhupur Sal forest or locally called Garh is a very promising place for practicing different types of crops in association with existing tree species. The forest area had severely degraded and depleted and the Bangladesh government started different agroforestry models in this area. Now a day, Madhupur Garh produces 60% of the country's total pineapple production through different agroforestry systems. In addition, farmers resided and used the forest land from time immemorial. They cultivated several types of agroforestry (tree-crop combination) systems and most of them are traditional having lower productive systems. Those agroforestry programs in the Madhupur region have begun massive diversity in the social relationships and interests among various stakeholders. On the contrary, these practices have enhanced the socio-economic condition of the local poor communities. Therefore, potential agroforestry models and their economic return towards developing community functions in the Madhupur Garh area of Bangladesh.

Sampling and Data Collection: The study obtained agroforestry farmers' initial information with the local people residing in the villages and from the respective offices. A pilot survey of five farmers was initiated in Madhupur. Later, the interview questionnaire was customized and scrutinized for collecting data. The data was collected through household interviews and focus group discussions. As for surveying farmers' households, the study took fifty farmers randomly from the eight villages. The elected farmers practiced local agroforestry on

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their farms. Interviews were taken with the assistance of a semi-structured questionnaire that covers farmers' socioeconomic information, their income from agroforestry practices, five livelihood capitals' improvement through agroforestry systems, and the challenges faced by the farmers. Along with the household interview, the study also undertook focus group discussions. The farmers were enlightened about the focus group discussion and their cognition was documented accordingly. Frequent conversation with farmers was made to validate the information. Finally, the obtained data were affirmed and cross-checked in the study. The period of data collection was in 2020-2021.

Analytical Framework: The study collected crops yield which was grown along with Acacia and Jackfruit trees and converted it to the hectare. Similar to the yield of crops, fruits, firewood, and other non-timber produces income were calculated on year per hectare. Finally, all of the products' income were calculated with their average market in Bangladesh Taka (1 USD ≈ 85 Taka). The Benefit-Cost Ratio (BCR) of the agroforestry models were calculated in which the rate of return per unit cost, by using the following formula, BCR = $\frac{\sum_{t=0}^{n} \frac{B_t}{(1+r)}}{\sum_{t=0}^{n} \frac{C_t}{(1+r)}}$ here, Bt= gross benefit in the i^{th} year, C_t= total cost in an i^{th} year, t= number of year and i= interest (discount) rate (11% interest rate assumed). Finally, the data were analyzed with the assistance of a computer program, Microsoft Excel for computing mean, graphs, BCR, etc.

RESULTS AND DISCUSSIONS

Economic Return of the Agroforestry Programs: The agroforestry models were implemented to uplift the income and livelihood of the farmers. The economic analysis revealed that all six models could generate income for the participants, of them, the Acacia-Pineapple-Ginger based agroforestry model produced the highest output of 546442 Taka followed by Acacia-Pineapple-Aroid (538907 TK), Acacia-Pineapple-Papaya (389107 TK), Acacia-Lemon (309371 TK), Acacia-Pineapple-Turmeric (275177 TK) and Jackfruit-Turmeric-Pineapple (227350 TK) models respectively (Table 1). The produces from tree income did not vary significantly as the total gross income of the agroforestry models relies on mainly crop income (Table 1).

Table 1. Cost of production, total income, and net income of agroforestry programs in hectare per year.

Items	**Agroforestry Models**					
	Acacia-Pineapple-Ginger (TK.)	Acacia-Pineapple-Aroid (TK.)	Acacia-Pineapple-Papaya (TK.)	Acacia-Pineapple-Turmeric (TK.)	Acacia-lemon (TK.)	Jackfruit-Turmeric-Pineapple (TK.)
Total labor cost	15970	25400	18400	17970	13970	16000
Sapling cost	3258	2965	2965	3258	3258	3258
Suckers cost	41933	42032	22032	21933	32933	9933
Rhizome/Seedling cost	20930	30132	8132	10930	20933	15930
Urea	28517	26771	12771	8517	12517	12517
TSP	24077	23543	9543	6077	1077	6077
MP	16416	16052	7052	5416	6416	5416
Cow dung	6578	6880	6880	6578	6578	6578
Pesticide & ethylene	2470	1399	1399	2470	2470	2470
Interest on operating capital	17987	8876	8878	12987	12700	12987
Land Cost	120564	140000	100648	112224	138731	126184
Timber income	297142	303457	206757	199600	210000	12500
Crop income	5340000	547000	292250	271337	350000	433000
Byproduct	14000	12500	8800	12600	9951	11700
Total Cost	298700	324050	198700	208360	260580	217350
Gross Return	845142	862957	587807	483537	569951	444700
Net Income	546442	538907	389107	275177	309371	227350
BCR	**2.83**	**2.66**	**2.56**	**2.32**	**2.19**	**2.05**

*Total income of trees was calculated in the yearly basis, TK (Bangladeshi Taka) = 85 USD.

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The cost of production of crops was higher at the beginning of the program cycle or years 1 and two. Accordingly, the cost of seedlings or planting materials was much higher in the first year, however, the labor cost of all models was higher than other costs. The cost occurred in the cultivation of 1 ha Acacia-Pineapple-Aroid model was the highest (324050 TK) and the Acacia-Pineapple-Papaya model was the lowest (198700 TK) (Table 1). The net profit of the different models showed that Acacia-Pineapple-Ginger is the most profitable agroforestry model in the study area and the cost of production of this model was quite minimum. Moreover, the Benefit-Cost Ratio is the indicator of economic analysis as it considers both costs and returns over the 10-year cycle of each agroforestry model. The results showed that the Acacia-Pineapple-Ginger was the most cost-effective model having the highest BCR (2.83).

Livelihood Improvement: Farmers who were practicing agroforestry in the Madhupur region were the poor people who do not possess distinct production and consumption option (Muhammed et al. 2008; Islam et al. 2012). After entangling in the program, they became capable to build their livelihood assets which in turn develop their community as well, and this study examines some major parameters of their community development.

The term "human capital" refers to the knowledge, skills, and capacity to work that are accessible to the participants. Human capital is a determinant in the volume and quality of labor availability at the home level; this fluctuates depending on family size, health condition, level of skills, and so on (DFID 2001). In the case of educational opportunities, it was found that participants had 70% opportunities, although the level kept improving (Table 2). Agroforestry practices supported education facilities for the rural community, specifically literacy spreading. Another significant human capital was the availability of labor in each household and it was quite clear that the participants had more opportunity to sell their labor resulting in income generation, job and employment opportunities.

Physical capital includes fundamental infrastructure and produces required to sustain livelihood. It comprises houses, tools that individuals own, rent, as well as public infrastructure to which they have an accession (DFID 2001). Housing is considered as one of the most essential assets for poor households since it is utilized for shelter and reproduction as well as income-generating reasons (renting rooms or utilizing the space) (Moser 1998). Physical assets, specifically in housing, altered significantly among the participants. Nowadays, houses built using brick walls and tin roofs show the common house formation in the rural areas of Bangladesh. The majority (78%) of the respondents' houses were made of mud-walls along with sun-grass roofs but some respondents (about 22%) had brick walls and tin-roof houses (Table 2). About 18% of the participants owned deep tube-well, whereas 82% of participants owned non-deep tube-well (Table 2). This study enclosed that the income of seasonal crop yield derived from the agroforestry practice was a significant factor influencing the attainment of such priceless appliances. The majority of the respondents had bought expensive appliances (e.g., Electricity).

Natural capital denotes the natural stocks from which provisions flow and services essential for surviving are derived (DFID 2001). It refers to the environmental resources like land and property resources, as well as free natural resources including woods, water, and pastures. In the agroforestry, program participants had tree stock on their land. Participants mentioned the antagonistic relationship with the Forest Department and their feelings of social insecurity (Figure 2). Seasonal crop income was a source of cash flow which used to achieve subsistence and buy other household goods for the respondents. The participants mentioned decreases in watersheds and biodiversity in the studied area because of climate change and overexploitation of the natural environment (Table 2).

Table 2. State of major features of the respondents and to the community

Parameters	Status and Trend
Literacy (Farmers)	70%, Sharply improving
Literacy (Children)	93%, Increasing
Dependency on loan	48%, Increase Microcredit/easy loan
Farmers' social relationship with other stakeholders of the community	Moderate, improving slightly
Tube-well (deep)	18%, improving sharply
Tube-well (non-deep)	82%, Improving
Toilet (Hygienic)	47%, Sharply improving
Household infrastructure	Tin-wall and Roof, change from mud-wall and sun-grass roof, Increasing physical assets
Electricity facility	Mostly Pollibidut, Improving
Road infrastructure to farm and markets	Brick and bitumen seal, Improving
Household animal	36%, Slightly decreasing
Animal farm	14%, Improving
Available of labor in the households	36%, Slightly decreasing
Tree stock in AF system	74%, Increasing
Watersheds cover	11.2%, Decreasing

Financial capital denotes the financial properties that people employ to meet their living goals (DFID 2001). Labor selling was frequently one of the most significant assets for poor people. Financial capital is classified into two groups: available stock (cash, bank savings, or liquid assets) and regular stock. The majority of members were taking out loans for seasonal agricultural cultivation, livestock keeping, housing repairs, or family illness. Typically, they acquired the loan through a local non-

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governmental organization (NGO) or, in certain cases, from family or neighbors. It was shown that just 24% of participants were able to obtain savings from various sources. Loans taken from families were generally free of interest, but loans taken from NGOs and other financial sources had an interest rate (15%). According to the study's participants' income sources, income from agroforestry practices was the primary root of their total yearly revenue, accounting for around 28% of percipients have the alternative income source like a household farm or others, respectively shown in Table 2.

There is a great argument over what is understood by the phrase "social capital" (DFID 2001). Social capital is defined as a web of mutual support that is observed in households, extended families, and communities and people can use to obtain, for example, loans, child care, food, housing, and information about employment and facilities of women take part in making a decision (Dersham and Gzirishvili 1998; Moser 1998). Furthermore, social capital is a significant resource for the poor, during times of crisis and socioeconomic conversion. The respondents were questioned about their participation with NGOs and other organizations, 28% of participants responded that they were involved with NGO, followed by 72% of participants who kept communication with other organizations. The number of NGOs and other organizations involved in the study area was more or less in the respondents' areas. Organizations worked to uplift the livelihoods of the poor people and allocated microcredit facilities for respondents. Because of a relationship, collective action sense had arisen between the participants and non-participants. The percentage of women's involvement with their husbands in making decisions was also found in a considerable rate of percentage (26%). Collective action is regarded as an essential asset for the sustainable management of natural assets. This action lasted within the participants but not within the society as a whole.

Social Relationship of the Participants: Social relationships and networks are valuable and critical resources for poor communities, specifically during times of family crisis and socioeconomic alteration. The study found that agroforestry created a new social platform and the farmers were organized as an independent social group. In a measurement scale of a 5-point Likert scale, (such as +2 strongly positive, +1 positive, 0 neutral, -1 negative, and -2 strongly negative) the study revealed that the farmers possessed a greater positive relationship among themselves (Figure 2).

However, the farmers showed a negative relationship with the local Forest Department and leaders, and the study found that forestland user rights and agroforestry program controlling power by the Forest Department have created distance with the local farmers, and local leaders support the Forest Department in this regard. Besides these two stakeholders, the local farmers possessed a good relationship with other stakeholders. Although networks and social relationships are attributes of an individual in a social context (Sobel 2002), the establishment of social assets depends on the institution, attitudes, and values that supervise interactions among farmers and provide to economic and social improvement (World Bank 2002); and the social capital of the participants in the study area has been improved.

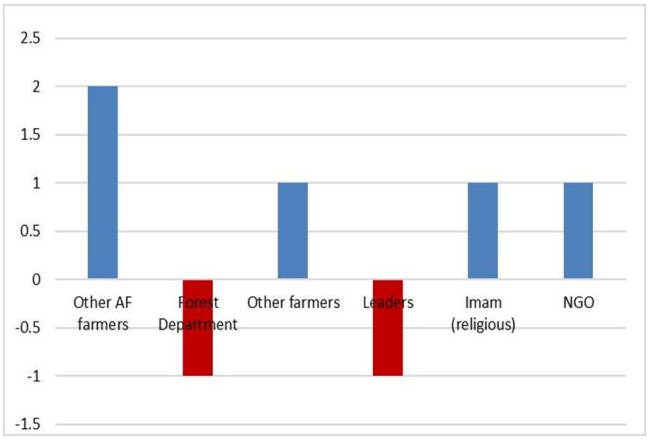

Figure 2. Impact of agroforestry on generating social capital of farmers.

CONCLUSION

This study affirmed that agroforestry may become an effective strategy for income generation for farmers. Subsequently, these agroforestry practices can be considered an economic success as a tree-crop production approach. Agroforestry in Bangladesh has a great potential for catalyzing the sustainable development of economies and helping to uplift the country's economy in the long term. It is important to mention that all stakeholders, especially the forest department, should take steps to make these programs sustainable. Findings from the study define that agroforestry practices have various impacts on the livelihoods of farmers. Local government authorities, in collaboration with other organizations, such as NGOs, can promote off-farm income generation opportunities. Therefore, it seems that agroforestry practices in the deforested land are not enough capable to protect and develop forests without ascertaining people's primary needs and day-to-day income sources. Only then, scientific and intensive management can influence the farmers' agroforestry practices. Thus, the future aims of agroforestry are to be managed simultaneously for sustainability and the socio-economic advantages of agroforestry-dependent people living in the Madhupur region. Agroforestry practices with such goals will earn, ensure the best outcomes from the land, income generation, sustainable productivity model, and improvement in the livelihood of farmers in the Madhupur Garh area of Bangladesh.

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