Original Article

Role of jackfruit based traditional agroforestry in farmers income and livelihood improvements: Evidence from Mymensingh district of Bangladesh

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A B S T R A C T

The agroforestry production systems provide products and services to support the basic needs and augment the livelihood of millions of farmers all over the world. In Bangladesh, the benefit of the traditional agroforestry systems and their livelihood development approaches are often not systematically addressed. Thus, the goal of the study was to evaluate the impact of traditional agroforestry on income generation and livelihood improvement of the rural farmers in Bangladesh. The study selected one of the most common jackfruit agroforestry cases practiced in the Mymensingh region of Bangladesh. The study was conducted in Muktagasa, Ghagra and Birunia, three villages located in the Mymensingh district of Bangladesh. The outcome revealed that the most common significant feature of the jackfruit-based agroforestry system was to generate income and diversified products for the rural farmers. Besides, the BCR was an evident indication of the income and livelihood developments of farmers. The rural farmers were able to build their finical, physical and natural capital strongly, while the social and human capital developments would require further attention. Also, the local marketing system was a constraint factor for the farmers, thus, the farmers could not get the proper price of their jackfruit in the peak season. The scientific training on jackfruit-based agroforestry farming systems and local conflict resolution mechanism process from the government levels would speed up the income generation and livelihood development of the farmers in Mymensingh region. Therefore, the study suggests to minimize the constraints of the agroforestry production systems through training, resolve marketing problems and also enhance social relationship through government official interference would be very effective to make the jackfruit-based agroforestry a more sustainable land-use practice in Bangladesh.

Introduction

Rapid population growth increases the demand for food, timber, fuel, fodder, fiber and other tree products, and also puts additional pressure on the existing forests. On the contrary, these forest ecosystems are expected to provide a diverse array of environmental services (Roshetko, 2013). Agroforestry can be a perfect solution to the uprising population of the developing world as it helps to make use of every piece of land sustainably. Agroforestry systems that rural communities have uplifted with scarce resources (e.g., land) to meet their household needs are a key opening to advance the sustainable use of forest products and services. Jackfruit (*Artocarpus heterophyllus*) perhaps the most widely distributed tree species in the genus *Artocarpus*, enjoys a dominant place in tropical agroforestry primarily on account of its multiple uses and amenability to integrate with other crop forms (Nair, 1989; Hossain and Haq, 2006).

Agroforestry is an integral part of the rural livelihood systems for centuries and plays a key role in providing household food and energy security, income and employment generation, investment opportunities and environmental protection in Bangladesh (Miah *et al*. 2002). The rural farmers of Bangladesh adopted many traditional agroforestry systems on their farms and sustain their livelihood. Alone with jackfruit, there are only a few traditional agroforestry systems are practiced in different agroecological zones in Bangladesh, and due to edaphic and climatic variation, these traditional agroforestry systems are

found mainly in specific locations. The jackfruit-based agroforestry systems can enhance farmers' earnings which has already been documented by the researchers (Rahaman *et al*. 2018; Hasan *et al*. 2008).

However, the livelihood improvement of the traditional agroforestry and its contribution to different asset development of the rural farmers have not alluded to extensively. Only a few previous studies have sporadically calculated income generation of the jackfruit trees in Bangladesh and as a traditional agroforestry system, the productivity of the system has not been assessed duly. The objectives of the study were to evaluate the impacts of jackfruit-based agroforestry systems on the income generation and livelihood development of rural farmers in the Mymensingh region of Bangladesh.

Theoretical frameworks: Most of the livelihood concepts have a focus on the household as the most appropriate social group for the investigation of livelihood. Several agencies (e.g., CARE, UNDP, FAO) have adopted livelihood approaches and make use of livelihood frameworks. This study used the DFID Sustainable Livelihood framework as a point of reference. The DFID's sustainable livelihood framework looks at the basic dynamics of livelihoods and how people are represented on a set of capital/assets as a basis for their livelihoods (Carney 1998; Hussein and Nelson 1998; Islam 2019). In the DFID's sustainable livelihood framework these assets are represented by – Human capital (skill, knowledge, capacity, labor ability, good health), Social capital (relationship of trust and reciprocity, networks, membership of groups), Physical capital (basic infrastructure, transport, shelter, communications), Natural capital (land, forest, water, wildlife, biodiversity) and Financial capital (monetary resources-savings, credit, remittances).

The traditional agroforestry systems in Bangladesh have been contributing to the livelihoods of the rural farmers mainly by contributing to the development of livelihood capitals. The assets are the livelihood building blocks and a range of assets are needed to attain positive livelihood outcomes (Islam and Sato 2012a, 2012, 2013; Warner 2003). Improvement in all the five capitals could be termed as strong improvement, while improvement in only some of the capitals that compensate for any decline in other capitals could be termed as weak or poor improvement of livelihoods (Das 2009). This study analyses the base assets of the participants and explores their access to livelihood assets in the context of the traditional jackfruit-based agroforestry systems (Shahabaz 2009). So, the livelihoods of the rural farmers have been evaluated in this study with the help of DFID's livelihood framework, particular the development of rural farmer's livelihood capitals.

Methodology
Description of jackfruit-based traditional agroforestry
Jackfruit (*Artocarpus heterophyllus* Lam.) is a famous tropical fruit in the world and ranks third in the area under cultivation and second in production among the fruits in Bangladesh (BBS 2018). Being the national fruit of Bangladesh the jackfruit can be grown all over the country. However, the soil and climatic (reddish soil with high humidity and rainfall) condition of the greater Mymensingh region is good for jackfruit production (Khan 2008; Ullah and Haque 2008). Traditionally the farmers of the Mymensingh region grow jackfruit in their cropland,

homegardens and other fellow lands as well (Figure 1). Farmers can grow different vegetables and cereal crops in association with jackfruit trees since the time memorial. However, the jackfruit tree having a wider canopy and extensive room systems which may compete with understory crops. Farmers in the Mymensingh region managed their jackfruit-based crop production through traditional knowledge, which may sometimes reduce the productivity of the agroforestry systems (Mia and Hussein 2010; Blanche 1999). Jackfruit tree bears fruit during April and ripening from June to August each year and farmers get a good amount of income from selling the fruits of jackfruit. Nevertheless, the timber of jackfruit is very useful for making furniture and thus, the farmers get a higher return in selling timber. The leaf of the jackfruit is also used for fodder.

Figure 1: Jackfruit based traditional agroforestry system in Mymensingh, Bangladesh

Study Area
The study was conducted in Muktagasa, Ghagra and Birunia, three villages located in the Mymensingh district of Bangladesh. The villages were belonging to the Old Brahmaputra Floodplain Agroecological zones (Figure 2) and the soil of the Mymensingh region is a non-calcareous dark grey floodplain and the average rainfall is 2541mm per annum.
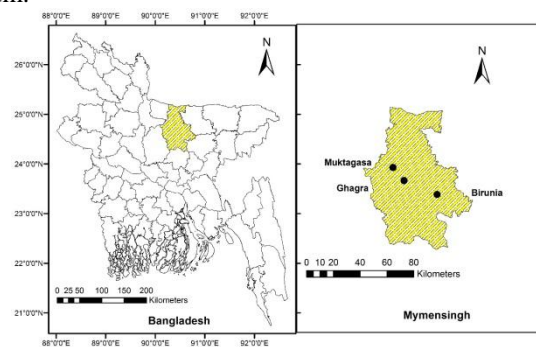
Figure 2: Study area map showing three location of the Mymensingh district (right)

The soil and climate of the Mymensingh region are good for vegetable cultivation as the soil is predominantly silt loams to silty clay loams. Farmers here grow different winter and summer vegetables like (cauliflower, cabbage, radish, etc.) and cereal and pulse crops (rice, lentils) in association with jackfruit trees.

Sampling and data collection
Before data collection, the study was collected traditional agroforestry farmers' information with an informal conversation with the local people of the communities and from the respective agricultural offices. A pilot survey of 5 farmers was conducted in the Mymensingh region and then the interview questionnaire was organized and confirmed for data collection. The preliminary data of this study was

obtained through household interviews and focus group discussions. For the farmers' household survey, the study selected 60 farmers randomly from the three villages, where 20 farmers represent from each village (Table 1). The selected farmers were practiced traditional agroforestry on their farms for more than 5 years. The interview was carried out with the assistance of a semi-structured questionnaire, which consists of farmers' socioeconomic information, their agroforestry income, improvement of five livelihood capitals through agroforestry systems and the problems faced by the farmers in the community. Interviews were held in the day-time with the help of two enumerators in the native Bengali language. In addition to the household interview, the study also conducted focus group discussions and in each of the villages, two focus group discussions were conducted. The farmers were informed about the focus group discussion and their perceptions were recorded accordingly. Repeated conservation with farmers was made in each common and decision-making question to ensure the validity of the information. Finally, the collected data were verified, cross-checked and authenticated in the study, the whole data collection period was conducted between 2019 and 2020.

Table 1. Sampling farmers in the Mymensingh area practiced jackfruit-based agroforestry

District	Upazilla	Village	Farmers
Mymensingh	Muktagasa	Muktagasa	20
	Mymensingh Sadar	Ghagra	20
	Valuka	Birunia	20

Data analysis
The jackfruit-based agroforestry provided varied outputs from crops and tree products. Crops were cultivated at a different time of the whole year and jackfruit tree provided fruit in the summer season of (May to August) Bangladesh. The study collected all crops yield grown in association with jackfruit tree and converted it to hectare basis. Like crop yield, all firewood, fruits, fodder and other non-timber products income were calculated on the year per hectare basis. Finally, all of the products' revenue was calculated with their prevailing average market price in Bangladeshi Taka (1 USD ≈ 84 Taka). The study also calculated the Benefit-Cost Ratio (BCR) of the Jackfruit-based traditional agroforestry system, which indicates the rate of return per unit cost, was calculated 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, B_t= gross benefit in i[th]year, C_t= total cost in

i[th]year, t= number of year and i= interest (discount) rate (assuming 11% interest rate). Finally, the obtained data were tabulated and analyzed using Microsoft Excel Software and statistical software package SPSS.

Results and Discussions
Demographic profile of the farmers
The study found that the variation of farmer households' size among the three villages was very insignificant and their average size was more than 6 (Table 1). The mean ages of the participants were 45.9 years (Table 1). The male and female ratio among the participant households was almost the same among the three villages. In the case of the literacy rate, the farmers from Birunia possess a slightly higher (52%) rate (Table 1) than the literacy rate of the overall civil district (Mymensingh) 43.5% (BBS 2013). The majority of

participants' religion was Islam and the rest was Hindu. The average landholding of households was 0.46 ha (Table 1) and the households' main sources of income are dominantly agriculture (Table 1).

Table 1. Demographic features of the respondent

Characteristics	Muktagasa	Ghagra	Birunia
Age (Mean)	45.6	44.60	47.5
Household size (Mean)	6.8	5.5	6.30
Male: Female ratio	48:52	50:50	48:52
Literacy rate	49%	42%	52%
Per household landholding (ha) (Mean)	0.52	0.48	0.40
Distribution of households by religion			
- Muslim	82%	89%	85%
- Hindu	18%	11%	15%
- Others	0%	0%	0%
Households main sources of income			
- Agriculture	65%	72%	75%
- Wage labor	15%	18%	15%
- Business	10%	8%	6%
- Unemployment	0%	2%	3%
- Remittances	5%	0%	1%
- Others	5%	0%	0%

Economic return from jackfruit agroforestry
Economic outcomes from the **tree-crop-based** agroforestry systems play a vital role in the household earning in rural farmers of Bangladesh. The traditional agroforestry system based on jackfruit was executed to promote the livelihood of the local community. The economic analysis showed that the outputs of traditional agroforestry mainly depend on the crops' income (Table 2). The Jackfruit based traditional agroforestry needs an intensive labor cost that was considered the main costs of the production systems. However, the jackfruit tree is habitually propagated through seeds and farmers did not need to pay a higher amount of money to buy and establish the jackfruit tree in their farms. The whole production costs and the average yield of the production systems are presented in Table 2.

Table 2. Economic analysis of the jackfruit agroforestry systems in Mymensingh region

	Items	Taka(1 USD ≈ 84 Taka)
Input	Tree saplings costs	15500
	Pit and land preparation costs	14233
	Planting and establishment of tree saplings costs	8850
	Tree pruning, training and other management costs	8467
	Vegetables cultivation costs	13008
	Other cereal crops cultivation costs	17517
	Labor costs	37633
	Manure and fertilizers costs	5833
	Insecticides and pesticides costs	5833
	Weeding and irrigation costs	6967
	Harvesting of crops and vegetables costs	12133
	Firewood and timber harvesting costs	4433
	Total costs	**150408**
Production/ Outputs	Income from firewood	36917
	Income from non-timber products	0
	Income from timber	107833
	Income from fruits	24533
	Income from fodder	7133
	Vegetable income	45417
	Cereal crops income	54650
	Income from crop residues	20467
	Gross Income	**296950**
Net Income		146542
BCR		**1.97**

It was evident that the farmers were cultivated different vegetables and cereal crops in association with jackfruit trees and earned a significant income (45417 and 54650 Taka), respectively (Table 2). The farmers sold the produced jackfruits and earned handsome money (24533 Taka). In addition to the timber and firewood income, the jackfruit leaves are used as fodder and sold in the local market which also provided an extra income (7133 Taka). The benefit-cost ratio (BCR) is a common indicator of economic analysis as it takes into account both costs and returns of both components. The BCR value of the jackfruit-based agroforestry showed 1.97 which is quite satisfactory in respect of the regions.

The study pointed out that the resilience of agroforestry farmers was strengthened through the locally adopted jackfruit species in their agricultural lands, which provide farmers a valuable source of income. The production systems outputs like timber, firewood, and fodder products were the backup against income risks in case of crop failure (Avelino *et al*. 2011; Branca *et al*. 2011). The outcomes of the agroforestry systems also revealed that the farmers get a continuous source of income throughout the year and the benefit-cost ratio of the systems was much higher than the general agriculture practices of the country (Islam 2019).

Livelihood development of the farmers
The rural poor farmers have practiced **jackfruit-based** traditional agroforestry system to support their daily living. After involvement in the program, they were able to build up several types of livelihood capitals and this study examines some important variables of these capitals (DFID 2001; Islam *et al*. 2012a, 2012; 2011).

A few training sessions and workshops (12%) were conducted by the local NGOs and GOs to familiarize the scientific training on agroforestry (Table 3). But it is not enough to train farmers effectively as the jackfruit-based agroforestry would require specific knowledge to manage the systems scientifically. Most of the farmers were thus used traditional knowledge to manage their production systems which they learned from their parents and grandparents. The literacy rate among farmers appeared to be improved slowly (48.5%) among the participants (Table 3). The available labor of the participants' families had decreased and it occurred due to the consciousness of education and migration to the capital city and suburbs for better livelihood, mentioned by the respondents. Food sufficiency of the household members throughout the year was found to be quite positive and improving after involving in the traditional agroforestry system. Nevertheless, poor populations living in rural areas normally have limited access to health services. In Bangladesh, the government health program tends to have better coverage in urban areas (Islam *et al*. 2012b). The participants were found to be capable to manage their family healthcare systems and visited the local clinic/hospital for the treatments. The income from the agroforestry systems was able to accommodate the farmers to visits the private clinic or local hospital, mentioned by the participants. So, the human capital of the farmers' was improved but not at a good level, three is ample scope to improve further.

Table 3. State of major characteristics of the participants in the community

Parameters	Status	Trends
Farmers Literacy rate	48.5%	Improving slowly
Children literacy rate	79%	Sharply improving
Involvement in social organizations	>6	Increasing
NGOs and GOs	>16	Increasing
Micro-credit and easy loan facilities	Good	Increase Microcredit/easy loan
Farmers received scientific training on agroforestry	12%	Not satisfactory
Farmers social relationship with other stakeholders of the community	Moderate	Not improving
Household infrastructure and physical assets	Tin-wall and Roof, shift from mud-wall house	Increasing physical assets
Road infrastructure to farm and markets	Brick and bitumen seal	Improving
Livestock small (e.g., chicken)	4.2	Increasing
Livestock big (e.g., cow, goat)	2.1	Slightly improving
Available of labor in the households	2.4	Slightly decreasing
Alternative market facilities to sell agroforestry products	Three	Not changing
Food sufficiency of the household members throughout the year	10 months	Increasing
Annual expenditure	96.8%	Slightly improving
Local Clinic and Hospital facilities for farmers	3.0	not changing but small clinic increasing in the village market area
Tree stock in household premises	18.2	Improving
Tree stock in AF system	46	Improving slowly
Alternative livelihood options	Exist	Increasing

Social relationships and networks are quite valuable and critical resources for impoverished people, exclusively during a family crises and socioeconomic changes. The study revealed that the jackfruit-based agroforestry generated a new social platform and the participants were assembled as an independent social group. The study found that the jackfruit-based agroforestry unleashed a new social platform and the participants were organized as an independent social group. In a measurement scale of a 5-point ranging from "Very Good" to "Very Bad", the study revealed that the participants possessed a very positive relationship among themselves (Table 4). However, the participants possessed a negative relationship with local elites and leaders, and the study found that they did not want to establish productive programs for the farmers. The participants reported that they got moderate support from agricultural offices and local government. Besides these two stakeholders, the 11 local participants possessed a good relationship with other stakeholders of the community. Although social relationship and networks are attributes of an individual in a social context (Sobel 2002), the establishment of social assets depends on the institution, attitudes and values that govern interactions among participants and contribute to economic and social development (World Bank 2002); and the overall social assets of the participants in the study area has been improved.

Table 4. Social relationship of the Jackfruit farmers in the community

Stakeholders	Relationship				
	Very Good	Good	Moderate	Bad	Very Bad
Jackfruit AF farmers	X				
Other Agricultural farmers		X			
Local leaders and elites				X	
Agricultural officers			X		
Local governments			X		
NGOs staff		X			
Religious leaders	X				

Here, AF=Agroforestry

Natural capital is the term used for the natural stocks from which resources flow and from which services, useful for livelihoods, are derived (DFID 2001). It refers to environmental assets such as land and common property resources or free (open access) natural resources such as forests, water, or grazing land (Islam *et al*. 2012). The land is an important natural capital and the respondents were categorized as either landless (having 0 to 0.2 ha land), marginal (0.2 to 0.6 ha), small (0.61 to 1.0 ha), medium (1.0 to 2.0 ha) or large (>2.0 ha) farmers according to their farmland area (Iqbal 2007). The participants were small farmers as they had less (0.62 ha) household land (Table 3). The study found out the farmers' perceptions towards conserving the Date palm trees were very positive and every farmer has maintained a good (around 90 trees per ha) number of trees in their farmland. Besides, farmers' awareness to preserve and maintain green cover in their homestead area was also high and they planted fruit trees in their homestead. On average each farmer has 18.2 tree species in their homestead, which provide diversified foods and nutritional sources for their family members. Therefore, the development of their natural capital was improving and the traditional agroforestry systems tend to improve the situation gradually.

Physical capital is comprised of the basic infrastructure and producer goods needed to support livelihoods. It includes assets such as housing, the tools and equipment that people own, rent, or use and the public infrastructure that they have access to (DFID 2001). Housing is normally one of the most important assets for poor rural households as it is used both for shelter and reproductive purposes and for productive or income-generating purposes (renting out of rooms or using the space as a workshop area) (Moser 1998). Nowadays, houses made using brick walls and tin roofs represent the standard house structure in the rural areas of Bangladesh (Islam *et al*. 2012). The majority (>70%) of the participants' houses were made of mud-walls with the tin roofs but some participants (about 30%) did have tin-wall and tin-roofed houses. On the contrary, local road infrastructure was gradually improved and mud-roads had been replaced by brick and bitumen sealed roads (Table 3). Participants were able to buy small and big livestock with the money they earned from the date-palm-based traditional agroforestry program. Moreover, few respondents stated that they bought

smartphones and television with the profit from the traditional agroforestry system. Farmers received a good amount of money after selling molasses in the winter seasons and able to buy some small and big livestock and often repaired their house structure. Therefore, the development of the physical asset of the traditional agroforestry farmers was a good sign to improve their livelihood.

Financial capital denotes the financial resources that participants use to achieve their livelihood objectives (DFID 2001). Income from the sale of labor was often one of the most important assets for the rural farmers. There are two main sources of financial capital: available stock (e.g., cash, bank deposit, or liquid assets) and regular flow of money (e.g., remittance, pension, and sale labor) (Islam *et al*. 2012b). The participants have been involved in different organizations to get loans and technical assistance to manage the Date palm-based traditional agroforestry program, and the study observed that farmers get loan facilities and micro-credit with the easy condition. The total tree and crop outputs are the strong financial assets of the farmers and farmers can invest these assets in their human, physical and other assets as well. The study found that the proper management of the agroforestry systems would strongly build farmers' financial capital (Table 3).

Major constraints of the program: The study also attempted to figure out the foremost obstacle that discouraged participants and affected the income generation of the jackfruit-based agroforestry model. Most of the participants (88.3%) reported that they did not get the suitable price for jackfruits (Table 5). They also mentioned that they were not enlightened enough to learn proper tree-crop selection and soil fertility issues.

Table 5. Major constraints faced by the Jackfruit agroforestry farmers (n=60)

Ranking	Problems	No. of farmers	Percentage
1	Do not get proper price of Jackfruits in the peck season	53	88.33
2	Lack of alternative market/market monopoly systems	36	60.00
3	Lack of tree-crop selection knowledge	28	46.67
4	Lack of soil fertility and nutrient status knowledge	27	45.00
5	Insects pests and diseases attacks to Jackfruit	25	41.67
6	Lack of improved variety saplings	24	40.00
7	Lack of cooperation of the agriculture office	21	35.00
8	Do not get easy or low interest free loan	18	30.00

Here, multiple answer recorded

The agriculture officials mentioned that they tried their best to cooperate with farmers but due to some official formalities and high officials' permission it took some time. One of the significant problems reported by the participants was the marketing monopoly and intermediaries, the government would need to improve the market monitoring systems to improve the condition (Islam *et al*., 2012b). Besides these problems, the local participants have faced a lack of vigorous seed/seedlings, pesticides, fertilizers and easy loans or low

credit loan facilities in their locality. In the study, it was revealed that these major problems have hindered the profitability of the agroforestry models and thus, affecting the participants' community improvement process.

Conclusion

Being a tree-crop-based production system, jackfruit agroforestry has numerous benefits that can contribute to rural farmers in respect of household income generation and livelihood improvements. The results of the study concluded that the jackfruit-based agroforestry has tremendous long-term benefits to farmers' total household income in maximizing the benefit-cost ratio of the farm. In addition, the rural farmers also faced some constraint which would hamper the productivity and outcomes of the traditional agroforestry system. The social relationship dynamics revealed that the participants had possessed a negative relationship with the local leaders and elites, and it is considered as one of the important issues to achieve the overall goal of the program. This community development process would speed-up by the active participation of local leaders, agricultural officers and local governments as facilitators in this concern. Now there is a current need to develop the livelihood of the farmers by providing them training on scientific agroforestry production and improve their relationship with other stakeholders in order to promote a more effective agroforestry system in the Mymensingh region of Bangladesh. Finally, the study can substantiate that the jackfruit-based agroforestry could be a more sustainable land-use system if the government and related stakeholders would provide their mutual support to the rural farmers and dissolve their production problem in a sustainable scheme.

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