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AGROFORESTRY PRACTICES IN BANGLADESH: PERSPECTIVES ON KNOWLEDGE, PERCEPTION, AND ECONOMIC BENEFITS

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Abstract

Agroforestry is one of the sustainable land management techniques, involving a combination of different agricultural, horticultural, and forestry practices to maximize productivity and sustainability of land. In disadvantaged locations such as char lands, a well-planned interacting land use system incorporating woody perennials in line with the farmers' needs can lead to a successful and sustainable farming system to dwindle poverty and eventually improve the food security. Agroforestry practices can serve this purpose in developing agro-based economy like Bangladesh. This study therefore is undertaken to reveal the farmer's knowledge on agroforestry practice, willingness to practice agroforestry and to examine the economic benefits of adoption of agroforestry. Following multistage random sampling technique, a total of 240 farm households were selected from certain char areas of Mymensingh, Jamalpur and Sherpur districts of Bangladesh. Socioeconomic characteristics of sample farmers were explored in terms of age, education, gender, farm experience, land ownership, etc. Farmers' knowledge, willingness, and adoption level of agroforestry were also examined. The majority of the farmers in the survey are aware with agroforestry practices (65%), but just a handful have actually used them. The farmers who adopted agroforestry practices or interested to adopt, expect support (cash or kind) from project or government. The tree species under agroforestry include Akashi, Eucalyptus, Mahogani, Mango, Jackfruit, Guava, Lemon, and Coconut. Financial or investment analysis of agroforestry adoption was done for several combinations of trees and vegetables.

Keywords: Agroforestry adoption; climate change; sustainable agriculture; Bangladesh.

1. Introduction

The predicted growth in world population from 7.4 billion in 2017 to 9.7 billion in 2050 (UN, 2019) has drawn a lot of attention as a factor influencing global food demand (Fukase & Martin, 2020). Between 2010 and 2050, total worldwide food demand is predicted to rise by 35% to 56%, while the number of people at danger

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of hunger is expected to rise. Moreover, the predicted growth in food production and its consequences for land use change, biodiversity, and environmental issues are strongly reliant on global food demand and consumption predictions (van Dijik *et al*., 2021; Hossain *et al.*, 2022).

Because of the increase in demand for agricultural resources as diets shift away from starchy staples and toward animal-based goods and fruits and vegetables, this growth convergence might have significant ramifications for global food consumption and agriculture (Fukase & Martin, 2020). This shift in diets have taken attention of all of the scientist and researchers all over the world. This event necessitates the invention of such method or system which can meet the future global demand of food as well as reduce environmental issues. Agroforestry can be the solution of solving such problems in the present context. Agroforestry can be identified as a promising option to meet society's demands and sustainable development models due to its benefits not only to the economy and society but also to the ecology (Jahan *et al.*, 2022). In developing nations, agroforestry is being encouraged to increase the productivity and sustainability of existing agriculture, particularly where monocrops are farmed on marginal areas (Nath et al., 2016). Agroforestry has many positive effects on farmers' livelihood through maximizing crop yields, reducing food insecurity, increasing income as well as improving farmers ability to cope with the effects of climate change by improving rain use efficiency and yield stability under rain-fed agriculture (Meijer *et al.*, 2014). Moreover, Agroforestry is a sustainable land management approach with an integration of agriculture, horticulture and forest to maximize productivity, profitability, minimization of resource and environmental risk. Agroforestry has gained popularity in recent years due to its potentiality to boost production, improve rural household security, and deliver regional environmental benefits (Jahan *et al.*, 2022). Agroforestry can be identified as a promising option to meet society's demands and sustainable development models due to its benefits not only to the economy and society but also to the ecology. Agriculture is progressing to the next level of sustainability thanks to agroforestry, which stimulates and executes bio-diverse (Jahan *et al.*, 2022).

As the population is rising quickly in Bangladesh, the quantity of land available for the development of new dwellings, factories, roads and highways, brickfields, hospitals, educational institutions, religious institutions, and other infrastructure is decreasing. On the other hand, because of increasing population demand of food is increasing too. As a result, one of the most common natural phenomena influencing the planet is forest conversion for alternative human benefit, which results in ecological devastation and global warming (Slingo *et al.*, 2005). Again, for ecological stability and sustainability, a country's total land area must have 25% forest land. Bangladesh, however, only has 17% of the land under forests, which are unevenly spread (BBS, 2013). This is very threatful for our country's overall

ecology. The only method to expand the forest is to plant trees, as there is no way to grow natural forest acreage to meet household demand for wood and fuel. Agroforestry, the technique of cultivating trees and crops on the same ground, with or without animals, is an important land-use system in developing countries (Jahan *et al.*, 2022) Homestead, cropland, farm boundary, roadside, railway side, embankment side, charland, coastal area, deforested area, institutional premises, riverside etc. are major venues for agroforestry practices. The scope of agroforestry is wide in Bangladesh (Nath *et al.*, 2016).

The Bengali name "Charland" means "Riverine Island" and refers to a mid-channel island that forms periodically from the riverbed as a result of accretion. Every year a large percentage of the char gets flooded and this situation threatens the livelihoods of people dependent on agriculture. Based on the potential and availability of land and the scope for improving productivity and benefits through agroforestry, char land areas are identified as a priority for research and development. Charland is the most important location for practicing agroforestry methods among them. Jamalpur, Sirajgonj, Noakhali, Bogra, Rangpur, and Mymensingh are the largest char-populated districts in Bangladesh. A vast number of people live in these char areas and rely on char-based farming systems for their livelihood. As a result, an integrated approach with crop and trees is required to increase productivity, maintain ecological balance, and improve the socioeconomic status of the Charland people (Rahman *et al.*, 2021). Agroforestry research and development has resulted in the advancement of scientific and technological advances (Brockington *et al.*, 2015). Because of their ability to mitigate the negative effects of intensively managed systems, agroforestry systems are gaining popularity in temperate climates. (Tsonkova *et al.*, 2018). Fruit-tree-based agroforestry is now popular that contributes to increasing total productivity and food security. The adoption and dissemination of new technologies depend on the diffusion of information through farmers interaction with extension agencies (Nath et al., 2016). Also, the uptake of agricultural innovation by smallholder farmers are less because of environmental degradation and climate change, lack of economic resources resulting in productivity. (Meijer *et al.*, 2014).

Several studies have addressed the adoption of agroforestry systems in different parts of the globe (Mfitumukiza *et al.*, 2017; Bayene *et al.*, 2019; Oduniyi and Tekana, 2019; Dhakal and Rai, 2020). Some studies also conducted in Bangladesh focusing on agroforestry adoption (Rasul and Thapa, 2006; Rahman *et al*., 2012; Sharmin and Rabbi, 2016; Saha *et al*., 2018); however, none of these studies was done focusing specifically on farmer’s knowledge, and perceptions regarding Agroforestry. Also, it finds in details data on support for agroforestry, perception towards agroforestry which ultimately help to adopt new technology like agroforestry. Besides, this study also makes an attempt to explore the respondents’ willingness and economic benefit of agroforestry in Bangladesh. To the best of our knowledge, this is the only study to figure out the farmer’s knowledge, and

perceptions regarding agroforestry in Bangladesh by collecting substantial primary data for robust findings. Thus, this study will contribute to the further research on agroforestry. Despite the fact that this research focused on Bangladesh, the findings may be generalized to other countries with comparable socioeconomic backgrounds.

2. Data and Methodology

2.1. Study areas and data collection

The present research is based on field level primary data collected from selected respondents through farm survey method. Keeping this view in mind, the researchers took paramount care for using proper methods in all aspects of this research within the encirclements of limited resources, materials and time. The current study was conducted in three Bangladeshi districts: Mymensingh, Jamalpur, and Sherpur. The research region is in Bangladesh's agro-ecological zone nine, often known as the Old Brahmaputra Floodplain.

Data collection was done by personal interviews. To collect the required data, a semi-structured interview schedule was created. A few Focus Group Discussions (FGDs) were performed before the interview schedule was created to learn about farmers' general perceptions and grasp of agroforestry. The input received during the FGDs was useful in planning the interview schedule. The interview schedule included information on household socioeconomic status, cropping patterns, cost and return statistics, and farmers' overall perceptions of agroforestry operations. Before finalizing the interview schedule, it was pre-tested with 10 farmers, and we made changes based on the results of the pre-test. Random sampling techniques were used to acquire data. Eighty samples were gathered from each district of Mymensingh, Jamalpur, and Sherpur, for a total sample size of 240. Two training programmes were conducted under this study to build capacity of the enumerators to collect accurate and adequate information and to manage, analysis and report data.

During data processing following steps had been taken.1) data entry and cleaning 2) coding 3) data validation 4) summarizing and scrutinizing the data for analysis. The socioeconomic information of the sample farmers particularly the family size and composition, age, literary level, occupation, land ownership pattern, and its distribution, their resource endowments etc were collected to understand the socioeconomic factors that are responsible for the adoption of agroforestry practices.

2.2. Empirical method

This part contains the study technique, which includes the description of descriptive statistics as well as the data analysis model. The descriptive statistics was used to depict the findings of socio-demographic profile of the respondents,

knowledge, perception and witlessness to adopt the agroforestry practice. The investment analysis was conducted to show the economic benefit of adopting agroforestry practice. We considered three popular combination of tress to show the best tree mix in an agroforestry practice. The benefits indicate the returns from agroforestry project sales i.e., quantity sold multiplied by the price of wood and non-wood items. Variable costs (e.g., land preparation, seedlings, planting, management, pruning, harvesting), overhead costs (e.g., cost of planning and compliance), capital costs (e.g., land purchase, machinery, depreciation), and opportunity costs (e.g., reduced gross margin from displaced livestock or cropping enterprises on land planted to trees) may all be included in the financial analysis. The financial analysis was conducted using discounted net present value (NPV), benefit-cost ratio (BCR), and internal rate of return (IRR). The discounting rate employed in this study is 10%. This indicates that the farmer thinks that if the money were not invested in the agroforestry project, the greatest alternative rate of return would be 10%. To put it another way, the opportunity cost of capital is 10%.

Mathematically, the NPV is calculated as:

$$NPV = \sum \left(\frac{B_i - C_i}{(1+r)^t}\right) = PVB - PVC \quad (1)$$

where B_i is the benefit in time t, C_i is the cost in time t, r is the selected discount rate, and t is time. The NPV is the difference between the present value of the benefits (PVB) and the present value of the costs (PVC). The monetary value and net present value are expressed in Bangladeshi Taka (BDT).

The BCR is a calculation that estimates the return on investment in an agroforestry project. It is calculated as:

$$BCR = \frac{NPV\ benefits}{NPV\ costs} \quad (2)$$

The discounted benefits of the project surpass the expenses if the ratio is larger than one. If it's less than one, the discounted costs outweigh the benefits, and the project should be thoroughly evaluated before moving forward (possibly accounting for unmeasured additional advantages).

The IRR of an agroforestry project represents the real rate of return on investment. We may use the IRR to compare various investments because it also provides us the discount rate. The IRR is calculated by continuing the process until the discount rate produces a net present value that is negative (NPV). Modern spreadsheets provide an IRR function investment that automates this iterative process and allows us to rapidly compute the IRR for a series of net cash flows in our project.

3. Results and Discussion

Sociodemographic Characteristics of Farmers

Farmers and their family members' socio-demographic features primarily highlight the wide range of interconnected social traits that have a significant impact on their economic activities, living conditions, and decision-making process. These qualities frequently influence a farmer's production strategy. Socioeconomic features may be viewed from a variety of perspectives, based on a variety of factors such as their socioeconomic status and the socioeconomic environment in which they live. Table 1 presents the socio-demographic profile of the selected respondents.

The respondents' age has a significant role in their willingness to participate in any income-generating activity. All of the sample farmers in the research region were divided into four age groups: those aged 20 to 30, 31 to 40, 41 to 50, and those aged above 50. The research reveals that the majority of the farmers in the research regions are either young (20-30 years old) or experienced (above 50 years old). In Mymensingh, 33.8%, 35% in Sherpur, and 27.5% of the selected farmers in Jamalpur, were in the 20-30-year-old age range. Only Mymensingh had the lowest 7.5% in the age range 31-40 years, while Jamalpur and Sherpur had the lowest in the age bracket 41-50%. Finally, the age group of more than 50 years was 32.5% in Mymensingh, 26% in Sherpur, and 35% in Jamalpur, respectively.

Education, in addition to skills and experience, has a significant influence on the modernisation of agricultural industry. It assists farmers in making the best decisions for their farm businesses by providing updated knowledge on new agricultural innovations. The majority of farmers in the study regions are illiterate. Mymensingh has the greatest illiteracy rate (57.5%), whereas Jamalpur has the lowest (47.3%). Some farmers have completed basic and secondary school, but just a handful have completed post-secondary education. As a result, it may be claimed that farmers find it difficult to absorb new technology and information, while technology suppliers find it difficult to inspire them.

The survey results show that some farmers in the research region work in a variety of vocations, despite the fact that agriculture (88.3%) is the primary source of income for the inhabitants in the study area. Aside from agriculture, some farmers work in trading, some in services, and just a few farmers work as housewives or students (Table 1).

Table 1. Socio-demographic factors of the selected respondents

Particulars	Region			All
	Mymensingh	Sherpur	Jamalpur	
Age of the respondents (years)				
20-30 (%)	33.8	35	27.5	32.1
31-40 (%)	7.5	25	23.75	18.8
41-50 (%)	26.3	13.75	13.75	17.9
More than 50 (%)	32.5	26.25	35	31.25
Education level of selected respondents (Years of schooling)				
Illiterate (%)	57.5	56.1	47.4	53.8
Up to primary (%)	20.0	29.3	20.5	23.3
Up to secondary (%)	17.5	7.3	20.5	15.0
Above secondary (%)	5.0	7.3	11.5	7.9
Occupation of the respondents				
Farming (%)	80.0	90.2	94.9	88.3
Labor (%)	3.8	1.2	1.3	2.1
Business (%)	13.8	0.0	1.3	5.0
Job (%)	0.0	1.2	1.3	0.4
Housewife (%)	1.3	0.0	0.0	0.8
Student (%)	1.3	7.3	1.3	3.3
Agricultural cultivable land (Average decimal)				
Own (decimal)	118.92	185.76	199.27	168.27
Leased in (decimal)	81.58	90.93	207.10	140.82
Leased out (decimal)	64.40	133.50	88.62	98.54
Total (decimal)	153.93	182.95	239.94	192.70
Land distribution in different sectors (Average decimal)				
Homestead area	24.96	35.25	27.75	29.17
Pond size	17.44	14.88	6.80	12.15
Forest	29.30	39.69	24.28	29.85
Others	30.00	5.00	2.85	5.27
Mean (Years)	24.55	20.33	23.54	22.78
Range (Years)	1-60	3-70	3-60	1-70
St. Dev. (Years)	12.85	13.791	16.382	14.45
Categories of farming experience (% of respondents)				
Up to 10	21.30	34.10	26.90	27.50
11-15	10.00	18.30	19.30	15.80
16-20	13.70	9.80	14.10	12.50
More than 20	55.00	37.80	39.70	54.20

Farm size refers to how much land a farmer owns and uses to grow a variety of crops and run profitable enterprises, as well as how it influences resource allocation. Sample families can be classified into three farm groups based on land ownership status: small (0.05-2.49 acres), medium (2.50-7.49 acres), and big (more than 2.50 acres) (7.50 acres and above). Small farmers found to dominate ranges of 78 to 88 percent of total samples across all areas. Farmers' land

holdings averaged 192.70 decimal, with the farmers of Mymensingh having the smallest (154 decimals) and the farmers of Jamalpur having the most (240 decimals).

Average land distribution for forest was found 29.85 decimal, while it was 29.30 decimal in Mymensingh, 39.69 decimal in Sherpur and 24.28 decimal in Jamalpur. The respondents' average agricultural experience was 22.78 years. A total of 54.20 % of farmers had more than 20 years of experience on the field. Mymensingh district has the most experienced farmers, while Sherpur had the least. Farm experience refers to knowledge or abilities in agricultural activities that a farmer has acquired through time by exercising or using their senses. Farming expertise is beneficial during the early phases of farmers' acceptance of new technology.

Financial analysis plays a vital role for the relatively realistic estimation of whether farmers are or will be profitable from exercising such practices (Duguma, 2013) as agroforestry is a long-term investment (Jara-Rojas et al., 2020) and financial capital consists of both stocks (e.g. bank deposits, jwellery or livestock) and flows (e.g. regular earned income or remittances). It is seen that access to bank, the percentage of farmers received credits, average amount of loan and the ranges of loans have some impact on farmer’s knowledge and attitude towards agroforestry. Usually, NGO disburses loan lower amount then that of bank and getting loan from bank still challenging for the farming community. The study reveals that the percentage of farmers received credits in Mymensingh, Sherpur, and Jamalpur region was 36.3%, 34.1% and 33.3% respectively in last five years. Aggregate annual earning is one of the important components for measuring the strength of financial capital. A farmer’s income can influence his knowledge, attitude and information towards anything related to agriculture. That is why, income status of our study regions farmers is necessary. Table 2 shows the average income of sample farmers from nine different sources. Most of the farmers in the study areas earn money from their crop selling as agriculture is their main occupation. The average income from crop selling was estimated at Tk. 95733, Tk. 111851, and Tk. 65421 for Mymensingh, Jamalpur, and Sherpur districts, respectively. As agroforestry is an important part of agriculture sector, income from tree and tree product source is important here to increase the knowledge, attitude and information sources of agroforestry.

3.1. Major pattern and plan distribution under agroforestry practices

Farmers, who practice agroforestry in their land, use on an average 30, 33, and 39 decimals of land in Mymensingh, Jamalpur, and Sherpur districts, respectively.

The average plants were 111 in average 39 decimals of land (Table 3). In Mymensingh, the plant species that are adopted by farmers include Akashi, Mahogoni, Lombu, Koroi, Mango, Jackfruit, Guava, Lemon, Litchi, and Coconut. In Sherpur, the tree species they adopted agroforestry practices include Eucalyptus, Mahogoni, Mango, Jackfruit, and Lemon. In Jamalpur, the tree species they adopted for agroforestry practices include Akashi, Eucalyptus, Mahogoni, Mango, Jackfruit, Guava, Lemon, and Coconut.

Table 2. Annual earning of respondent households

Yearly family income (Tk.)	Region			Total
	Mymensingh	Sherpur	Jamalpur	
Income from crop selling	95733.33	111851.85	65421.05	91431.03
Income from tree and tree product	22075.12	29797.30	24303.03	25529.37
Income from Livestock poultry	41346.15	44484.62	43651.67	43280.23
Income from fisheries ponds	69000.00	70555.50	21333.33	59452.36
Income wages and salaries	87388.89	128625.00	135272.73	110540.54
Income small business	63812.50	131428.57	164571.43	114729.73
Income from Remittances	0.00	0.00	440000.00	440000.00
Govt support or grants	10000.00	0.00	0.00	10000.00
Others	0.00	0.00	63000.00	63000.00
All average	389356	516743	957553	957963

Table 3. Average area and plant under agroforestry practices

Criteria	Mymensingh	Sherpur	Jamalpur	All
Area (decimal)	30.22	33.36	47.93	38.77
Average plant	44.70	162.79	141.24	110.57

Table 4. Number of plants produced per decimal and per hectare

District	Per decimal	Per hectare	Type of plant	Per decimal	Per hectare
Jamalpur	3.02	744.12	Wood	3.30	812.95
Mymensingh	2.03	500.02	Fruits	2.51	623.34
Sherpur	3.87	979.71	Medicinal	2.40	592.33
Total	2.84	702.36	Others	1.20	296.00
			Total	2.84	702.36

Distribution by plant name

Plant name	Per decimal	Per hectare	Plant name	Per decimal	Per hectare
Akashi	4.46	1097.38	Jackfruit	1.58	386.56
Amloki	3.60	889.00	Koroi	1.68	413.00
Boyra	1.50	370.00	Lemon	6.19	1522.93
Coconut	1.24	333.00	Litchi	1.03	253.60
Drum stick	1.20	296.00	Mahogany	1.91	471.56
Guava	2.77	680.67	Malta	3.00	740.00
Haritaki	2.40	592.00	Mango	1.79	442.85

Natural capital holdings have a very close relationship with knowledge, attitude and information sources of agroforestry. Those who have more forest and

cultivable land they have positive attitude about learning new techniques that can be agroforestry. Land, forest, pond are the main natural resources belong to rural households. On their own land they cultivated different crops and vegetables seasonally which is the basic income source of the farmers. It was found that the sample households own 193 decimals of land for cultivation. They also possess 30 decimals of forest and 12 decimals of pond. The households of char land own on average 30-50 trees as natural and Akashi seems to require less land and can be produced more per unit of land according to Table 4.

The agroforestry system of vegetable farming is well-known in the Old Brahmaputra floodplain scheme. This system includes Mymensingh, Jamalpur, and Sherpur, which are all part of our research region. In this region, a wide range of vegetables are cultivated under various cropping patterns, with variations from one location to the next. Rice, jute, brinjal, potato, tomato, chili, and red amaranth are the most prevalent crops and vegetables planted by the sample farmers. Table 5 shows the details of major crops and vegetables produced in Mymensingh, Jamalpur and Sherpur District.

Table 5. Types of crops and vegetables grown by the sample farmers

District	Name of crops and vegetables
Mymensingh	Rice, Wheat, Jute, Sweat gourd, Potato, Brinjal, Bottle gourd, Raddish, Cabbage, Chili, Mustard, Carrot, Cucumber, Amaranth, Red amaranth, Okra, Grass pea, Sweet potato.
Jamalpur	Rice, Wheat, Jute, Cotton, Sweat gourd, Sweet potato, Brinjal, Amaranth, Red amaranth, Onion, Tomato, Okra, Ginger, Cauliflower, Mashkalai, Bean, Chili.
Sherpur	Rice, Jute, Maize, Sweat gourd, Potato, Brinjal, Tomato, Chili, Red amaranth, Peanut, Grass pea, Chili, Cauliflower, Cucumber, Bean, Bottle gourd, Raddish.

3.2. Knowledge about agroforestry practices

The important benefits of agro-forestry which perceived were that it helps in becoming 'self-reliant' in terms of fuel, fodder, timber and other minor forest produce (MFPs), 'helps in increasing soil fertility, checking soil erosion and retention of soil moisture', 'capable of improving socio-economic conditions of the farmers', 'meeting the raw material demands of forest based industries', 'overall increase is more than pure forestry and agriculture land use', 'solving un-employment problem', etc. According to the survey, 70% of farmers in Mymensingh said they'd heard of agroforestry, but that doesn't indicate they're using it (Table 6). Agroforestry was used by 30% of these farmers. Despite the fact that the majority of farmers have never practiced agroforestry, they are eager to do so. On Sherpur, 46% of farmers said they'd heard of agroforestry, and 30% of them said they'd tried it in their fields. Approximately 67 percent of farmers said they had market access for the items they produce, which is lower than in Mymensingh

and Jamalpur districts, suggesting that market facilities in this area should be enhanced. In Jamalpur, 77% farmers mentioned that they have heard about agroforestry within which 39% practiced this. About 96% farmers mentioned that they have market access for the products they produce.

Table 6. Information about agroforestry practices

Particulars	% of farmers response yes			Total
	Mymensingh	Sherpur	Jamalpur	
Familiar with agroforestry	70.0	46.3	76.9	64.2
Experience in agroforestry	30.0	30.5	38.5	32.9
Received support	12.5	7.3	26.9	15.4
Access to market	90.0	66.7	96.4	89.7

3.3. Source of information

Information is a very important element before doing a task. When one has proper information about a task or a thing, one can easily gain knowledge about it. Depending in the degree of access to information, knowledge can vary from person to person. Types of information source and the interest to take information from those sources affect a person's attitude too. Agricultural information to farmers has been highlighted as critical agent needed to transform subsistence farming into a modern and commercial agriculture. The present study investigated the information sources of agroforestry practices available to the farmers. Figure 1 portrays the information sources related to agroforestry practices in the selected districts and in total. In Mymensingh, farmers got information mainly from the Bangladesh Agricultural University followed by Agriculture offices, relatives, and neighbours. In Sherpur, 32% farmers got information from Agriculture office, mainly BARI followed by neighbours, NGOs, relatives, and university. In Jamalpur, most of the farmers got information from Agriculture office, i.e. BARI.

Extension services play a vital role in providing different information and guidance that is needed for the development of knowledge, skills, practices and improvement of livelihood as well**.** But from the survey, extension staff in char areas are not the most effective to visit communities. About one-third to one-fifth of farmers reported that they have not seen any extension staff visited to their locality (Table 7). In contrast, about 50 % of the farmers never visit to the extension office. Again, a good portion of the respondents (17 to 25 %) reported that they rarely visit to the extension office as well as extension staff also visit rarely (33 to 38 %) to them. A few percentages of the farmers often visit to the extension office for advisory services. It can be said that delivery of extension services to the door steps and farmers interest to gather information from extension office were found at lower level. This is not unexpected as the study samples were drown from char areas.

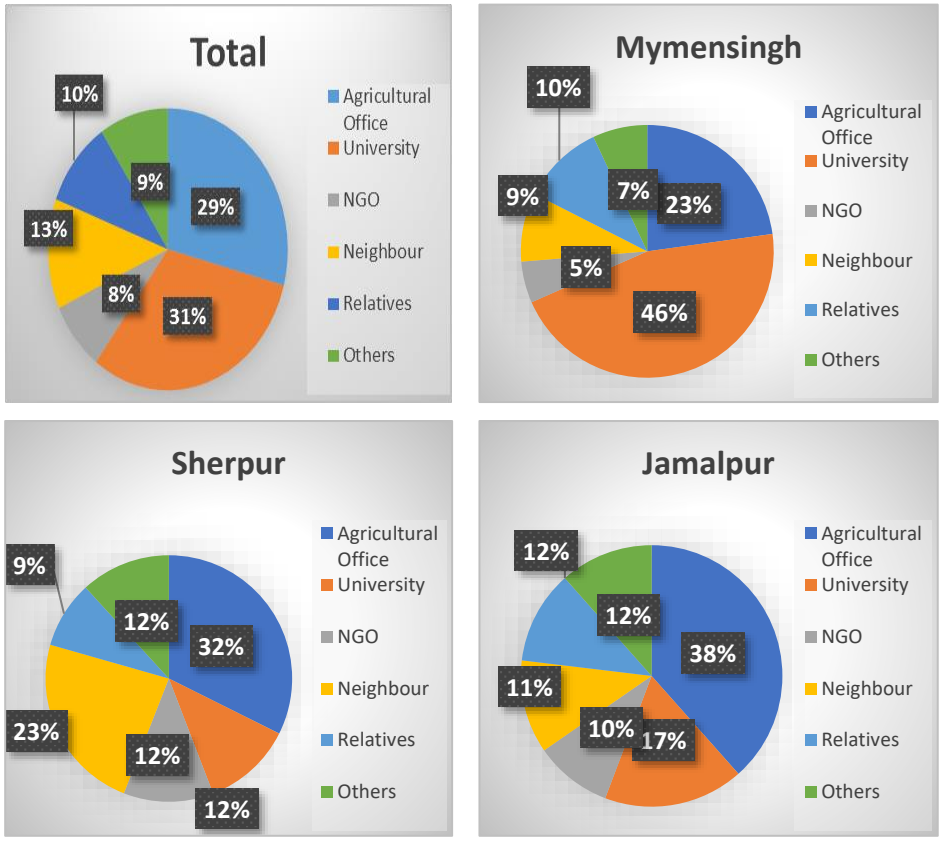

Figure 1. Agroforestry information sources to the farmers

Table 7. Mode of extension services received by the respondents

Particulars	Region			Total
	Mymensingh	Sherpur	Jamalpur	
Visit of extension staff (percentage)				
Not at all	21.6	17.6	30.3	23.2
Rarely	32.4	37.8	32.9	34.4
Yearly	14.9	10.8	3.9	9.8
Once in a month	25.7	20.3	11.8	19.2
Quite often	5.4	13.5	21.1	13.4
Respondents visit to extension office (percentage)				
Not at all	46.5	51.5	61.8	53.5
Rarely	25.4	17.6	17.1	20.0
Yearly	5.6	8.8	1.3	5.1
Once in a month	16.9	16.2	10.5	14.4
Quite often	5.6	5.9	9.2	7.0

3.3.2. Access to support of agroforestry

Bangladeshi farmers are gradually embracing agroforestry using indigenous knowledge on a small scale rather than commercialization using advanced scientific knowledge (Hanif et al., 2018). In Bangladesh, the majority of farmers still lack appropriate understanding regarding agroforestry operation and management. As a result, they are less concerned with combining different trees to maximize returns (Jahan et al., 2022) That is why support of agroforestry is needed in input sector as well as in case of trainings also.

Farmers were found to receive the majority of their help in the form of seed/seedlings and training. In Mymensingh, around 4% of sample farmers received seed, 10% received seedlings, 2.5% received labor, and 5% received instruction to help them conduct agroforestry. A few farmers received help with fertilizer, irrigation, and herbicides (Table 8). Only 2.4% of the farmers in Sherpur received assistance, and it was limited to seed or seedlings. In Jamalpur, 6% of farmers received seed, 22% received seedlings, 5% received labor, 10% received fertilizer, and 22% received instruction to help them implement agroforestry. They received an average of 1 kg of seed and 17 seedlings per area. They received 6 labor, 60 kg fertilizer, 850 Tk for irrigation, 300 Tk for pesticides, and 694 Tk for training on average in Mymensingh and Jamalpur. Farmers are unable to sell their produce at the market due to a lack of assistance. Table 6 provides more information on market support.

Table 8. Information about support services to practice agroforestry

Type of support	Yes (%)	All average	Mymensingh		Sherpur		Jamalpur	
			Yes (%)	Amount	Yes (%)	Amount	Yes (%)	Amount
Seed (Kg)	4.2	1	3.8	2.33	2.4	0.57	6.4	5.0
Seedling (No.)	11.3	17	10.0	50.63	2.4	35	21.8	42.57
Labor (No.)	2.5	5.75*	2.5	3.0	0.0	0.0	5.1	8.5
Fertilizer (Kg)	3.8	60*	1.3	100	0.0	0.0	10.3	19.57
Irrigation (Tk.)	0.8	850*	1.3	500	0.0	0.0	1.3	1200
Pesticide (Tk.)	0.8	300*	1.3	300	0.0	0.0	1.3	300
Insecticide (Tk.)	0.4	200**	1.3	200	0.0	0.0	0.0	0.0
Market support	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Training (Tk.)	8.8	694*	5.0	733.33	0.0	0.0	21.8	655.55
Fencing net	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* Average of Mymensingh and Jamalpur; ** Mymensingh only.

3.4. Farmers' willingness and perception towards practice agroforestry

There are variations in sample farmers in terms of knowledge, attitude and adoption level regarding agroforestry practices. There are some farmers who never heard about agroforestry. Some were practicing agroforestry while some were interested to do agroforestry. They study therefore interested to know the percentage of the

farmers who are currently doing agroforestry and will continue this practice in future. In addition, it was also investigated who are interested to start this practice. Table 9 shows that in Mymensingh, 72% farmers who are familiar with agroforestry practices are doing this and among them 93% will continue this practice. Farmers who are practicing agroforestry, 50% are doing this practice with support and 50% are doing without support. Farmers who wish to continue in future, mentioned that they will continue this practice if they get support (86%). However, 14% replied that they will continue this practice even they will not get any support. In Sherpur, 67% farmers who are familiar with agroforestry practices are doing this and among them 93% will continue this practice. Farmers who are practicing agroforestry, 75% are doing this practice with support and 25% are doing without support. Farmers, who wish to continue in future, mentioned that they will continue this practice if they get support (100%). Nobody replied that they will continue this practice without support. In Jamalpur, 32% farmers who are familiar with agroforestry practices are doing this and among them 96% will continue this practice. Farmers who are practicing agroforestry, 72% are doing this practice with support and 28% are doing without support. Farmers, who wish to continue in future, mentioned that they will continue this practice if they get support (53%) and 47%mentioned that they will continue this practice even they will not get any support. Among the farmers, who are not currently practicing agroforestry, 51% in Mymensingh are interested to start agroforestry in future and half of them expressed interest for support while half of them said that they are interested even without support. The similar situation was found in Jamalpur district. However, in Sherpur the percentage of interested farmers is very low (5%). This may be the lack of knowledge and information they got about agroforestry.

Table 9. Farmers' willingness to practice agroforestry

	Mymensingh (%)			Sherpur (%)			Jamalpur (%)		
	Yes	WS	WOS	Yes	WS	WOS	Yes	WS	WOS
Continuing	72.0	50.0	50.0	66.7	75.0	25.0	32.1	72.0	28.0
Future continue	92.9	86.4	13.6	92.9	100.0	0.0	96.4	83.3	16.7
Interested in agroforestry	51.2	51.2	48.8	4.9	45.1	54.9	46.2	52.6	47.4

WS=With support; WOS= Without support.

Farmers, who are practicing agroforestry in their field, received or bought seed or plant from different sources (Figure 2). The main sources for seed or plant are market, agricultural offices, project, NGO, Seed Company, and others. In Mymensingh, 56% farmers bought seed/plant from market. In addition, 15% got seed or plant from the project (i.e. NATP phase-1 project), 15% from agriculture offices, and some 12% from relatives or neighbors. In Sherpur, most of the farmers (84%) purchased seed or plant from market followed by others (relatives, neighbors, etc.). In Jamalpur, 39% farmers used the market source for their seed or plant. They also got these from others (37%), and from agriculture office (i.e. BARI).

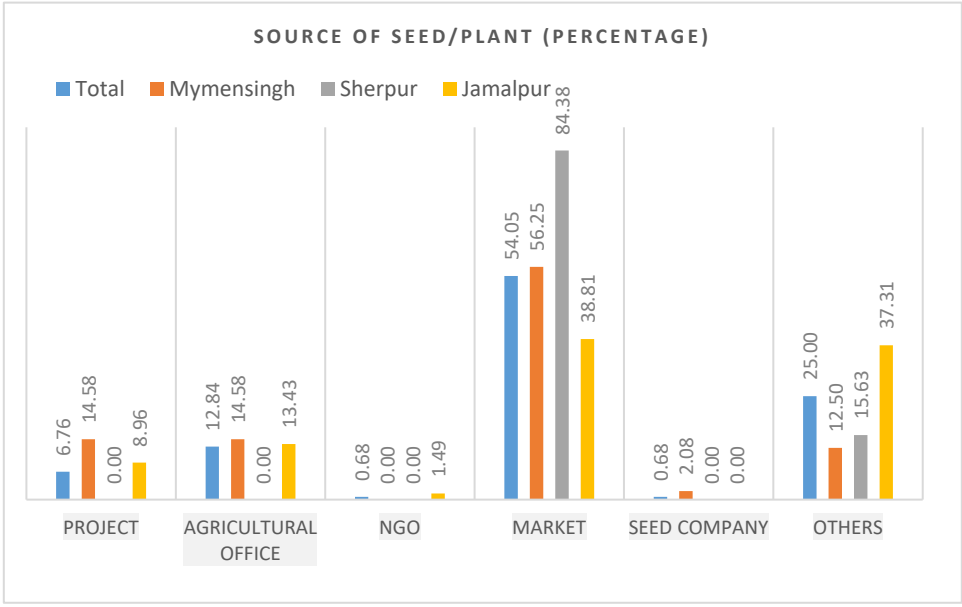

Figure 2. Source of Seed/plant for agroforestry practices

3.5. Economic Benefits of adoption of Agroforestry Practices

The profitable and income generation way is the combination of cultivating vegetables and trees as well. Mahogany is an excellent choice for a rice field boundary plantation and growing this economic tree zonally or sequentially with crops on the same piece of land that offers a good production strategy (Noman et al., 2018). Here, the study provides the financial analysis of mahogany tree combined with chili. In this combination, first year cost was estimated as the highest as most of the investment was done in first year including land preparation and plantation. Later, the cost was reduced slightly over the years. In the subsequent years the costs include operation and maintenance cost, thinning, pruning, etc. Encouragingly, from the beginning of the investment agroforestry system generated revenue because of vegetables production although net cash flow was a bit negative. It is observed that in the first three years, revenue was generated through vegetables production (chili in this case) which could not be possible without adopting agroforestry practices. The highest amount of revenue obtained in the 10^{th} year of tree plantation when first sale from the tree occurred. Accordingly, the net cash flow was also appeared as the highest at that year. Finally, NPV, BCR, and IRR were estimated based on the discounted value method. Table 10 present the details of cost and return of Mahogany Tree with Chili cultivation in the study areas.

Table 10. Investment Analysis for Mahogany Tree with Chili

(BDT '000'/ha)

Year	Activity	Direct cost (A)	Opportunity cost (B)	Total Cost (A+B)	Revenue from trees (C)	Revenue from Chili	Total Revenue (C+D)	Net Cash flow (A-B)	Net cash Position (Cumulative)
0	Establishment cost	327	76	402	0	395	395	-7	-7
1	Operation & Maintenance (O&M) cost	273	71	345	0	395	395	50	44
2	1st pruning + O&M	279	72	350	7	216	224	-127	-127
3	1st thinning + O&M	45	53	98	12	0	12	-86	-212
4	2nd Pruning + O&M	20	51	71	12	0	12	-58	-58
5	O&M cost	10	50	60	0	0	0	-60	-119
6	O&M cost	10	50	60	0	0	0	-60	-60
7	O&M cost	5	50	55	0	0	0	-55	-115
8	O&M cost	5	50	55	0	0	0	-55	-55
9	Harvest 50% @2500/tree	10	50	60	1853	0	1853	1792	1738
10	O&M cost	5	50	55	0	0	0	-55	-55
11	Harvest 25% @3000/tree	10	50	60	1081	0	1081	1020	966
12	O&M cost	5	50	55	0	0	0	-55	-55
13	O&M cost	5	50	55	0	0	0	-55	-110
14	Final harvest saw long @3500/tree	15	51	66	1235	0	1235	1169	1169

The estimated NPV, BCR, and IRR were found as below:

NPV=Tk.1076,000/ha; BCR=1.21; IRR=42%

Likewise, mahogany, investment analysis of akashmany with other vegetables practices were done. The study of Alam et al. (2012) support this finding that summer vegetables cultivation with the combination of different fruit, timber and soil conserving tree species can be a profitable agroforestry practice in charland areas. Here, in case of akashmoni with combination of brinjal, the most cost was incurred in the first year. Since, it is an agroforestry system, revenue can be earned from the first year by selling vegetables (brinjal in this case). The revenue from tree started from the 10^{th} year and continued until 15^{th} year.

In general, for any investment, no return is expected for first couple of years as initial investment cost is higher for first few consecutive years which is true for sole plantation also. But for agroforestry practices revenue is generated from the beginning of the investment as revenue is obtained from vegetables production hence the net cash flow for agroforestry combination shows relatively lower negative value. Table 12 presents the details cost and benefit analysis of Lambu Tree with Bitter gourd cultivation.

Table 11. Investment Analysis for Akashmoni Tree with Brinjal

(BDT '000'/ha)

Year	Activity	Direct cost (A)	Opportunity Cost (B)	Total Cost (A+B)	Revenue from trees	Revenue from	Total Revenue	Net Cash flow (A-B)	Net cash Position
0	Establishment cost including fence	414	83	496	0	494	494	-2	-50
1	Operation & Maintenance (O&M) cost	367	79	446	0	494	494	48	-49
2	1st pruning + O&M	372	79	451	7	395	403	-49	-96
3	1st thinning + O&M	45	53	98	12	0	12	-86	-182
4	2nd Pruning + O&M	20	51	71	12	0	12	-58	-58
5	O&M cost	10	50	60	0	0	0	-60	-119
6	O&M cost	10	50	60	0	0	0	-60	-60
7	O&M cost	5	50	55	0	0	0	-55	-115
8	O&M cost	5	50	55	0	0	0	-55	-55
9	Harvest 50% @3500/tree	10	50	60	2161	0	2161	2101	1738
10	O&M cost	2	50	52	0	0	0	-52	-52
11	Harvest 25% @4000/tree	10	50	60	1235	0	1235	1175	969
12	O&M cost	5	50	55	0	0	0	-55	-55
13	O&M cost	5	50	55	0	0	0	-55	-110
14	Final harvest saw long @4500/tree	15	51	66	1389	0	1389	1324	1169

The estimated NPV, BCR, and IRR were found as below:

NPV=Tk. 1,370,000/ha; BCR=1.21; IRR=65%

Table 12. Investment Analysis for Lambu Tree with Bitter gourd

(Per hectare in BDT '000')

Year	Activity	Direct cost (A)	Opportunity Cost (B)	Total Cost (A+B)	Revenue from trees (C)	Reve-nue from Bitter gourd (D)	Total Revenue (C+D)	Net Cash flow (A-B)	Net cash Position (Cumulative)
0	Establishment cost including fence	289	73	362	0	356	356	-6	-6
1	Operation & Maintenance (O&M) cost	242	69	311	0	320	320	9	3
2	1st pruning+ O&M	247	69	317	7	285	292	-25	-25
3	1st thinning +O&M	45	53	98	12	0	12	-86	-110
4	2nd Pruning+O&M	20	51	71	12	0	12	-58	-58
5	O&M cost	10	50	60	0	0	0	-60	-119

Year	Activity	Direct cost (A)	Opportunity Cost (B)	Total Cost (A+B)	Revenue from trees (C)	Reve-nue from Bitter gourd (D)	Total Revenue (C+D)	Net Cash flow (A-B)	Net cash Position (Cumulative)
6	O&M cost	10	50	60	0	0	0	-60	-60
7	O&M cost	5	50	55	0	0	0	-55	-115
8	O&M cost	5	50	55	0	0	0	-55	-55
9	Harvest 50% @2200/tree	10	50	60	1494	0	1494	1434	1379
10	O&M cost	2	50	52	0	0	0	-52	-52
11	Harvest 25% @2800/tree	10	50	60	951	0	951	891	839
12	O&M cost	5	50	55	0	0	0	-55	-55
13	O&M cost	5	50	55	0	0	0	-55	-110
14	Final harvest sawlong @3200/tree	15	51	66	1087	0	1087	1021	1021

The estimated NPV, BCR, and IRR were found as below:

NPV=Tk. 889,000/ha; BCR=1.12; IRR=43%

According to BCR, IRR, and NPV calculations, NPV is positive, BCR is more than 1, and IRR exceeds the opportunity cost of capital (10% here). As a result, mahogany with chili may be recommended as a profitable tree mix, and farmers will benefit from investing in this farm business. The estimated BCR, NPV, and IRR all come out positive, indicating that combining akashmoni with brinjal is a viable investment option for farmers. An examination of an agroforestry practice (lambu with bitter gourd) reveals that the NPV is positive. The NPV and IRR for agroforestry operations are likewise higher than for tree planted alone. As a result, we can observe that agroforestry is far superior to tree plantation.

4. Conclusion

This study attempted to identify the knowledge, and adoption behaviour of farmers regarding agroforestry. To satisfy the objectives of the study, this study employed descriptive and financial analysis. Results revealed that about 64% farmers replied that they have heard about agroforestry but this doesn't necessarily mean that they are practicing agroforestry. Among them 33% farmers practiced agroforestry. Although most of the farmers never practiced agroforestry but most of them are interested to adopt agroforestry practices. It was found that farmers received support mainly in terms of seed/seedlings and training. On average, 15% farmers got seed/seedlings support and 9% farmers got training support. The percentage is low as there are small numbers of farmers in the study area who practice

agroforestry. The main sources for seed or plant are market (54%), agricultural offices (13%), project (7%), NGO (1%), Seed Company (1%), and others (25%).

The findings also revealed that the NPV, BCR, and IRR of agroforestry practices meet the economic advantage of the activity, allowing farmers to embrace it. The Akashmoni Tree with Brinjal yielded the most economic advantage of every tree combination. Under the current framework, agro- forestry was identified as a viable alternative to conventional farming systems by farmers, at least in less productive areas. Furthermore, the role of modern agroforestry to improve biodiversity, soil, and water quality should be better recognized by existing policy measures providing payments for environmentally friendly farming.

The successful promotion and implementation of agroforestry among smallholders will require the adoption of a participatory approach in project planning and implementation. Smallholders' attitudes, needs, preferences and traditional knowledge are crucial factors to take into account in any project. Finally, it can be concluded that the successful adoption of agroforestry to raise farm productivity and overall income of the respondents in the study area depends on raising awareness on benefits of agroforestry, providing adequate technical supports as well as ensuring the efficient use available farmlands of all types of landholders.

References

Alam, Z.; M.A. Wadud and G.M.M. Rahman (2012). Performance of summer vegetables in charland based agroforestry system. *Journal of Agroforestry and Environmen*t, **6**(1): 1-8.

BBS (2003). Statistical Yearbook of Bangladesh-2002. Bangladesh Bureau of Statistics (BBS). Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Beyene, A.D.; A. Mekonnen, B. Randall and R. Deribe. (2019). Household level determinants of agroforestry practices adoption in rural Ethiopia. *Forests, Trees and Livelihoods*, **28**(3): 194-213.

Brockington, J.D.; I.M. Harris and R.M. Brook (2016). Beyond the project cycle: a medium-term evaluation of agroforestry adoption and diffusion in a south Indian village. *Agroforestry systems*, **90**(3): 489-508.

Dhakal, A. and R.K. Rai (2020). Who adopts agroforestry in a subsistence economy? — Lessons from the Terai of Nepal. *Forests*, **11**(5): 565.

Duguma, L.A. (2013). Financial analysis of agroforestry land uses and its implications for smallholder farmers' livelihood improvement in Ethiopia. *Agroforestry systems*, **87**(1): 217-231.

FAO (2011). Save and grow: a policymaker's guide to the sustainable intensification of smallholder crop production. FAO, Rome.

FAO, (2010). The state of food insecurity in the world. Rome: Food and Agriculture Organization of the United Nations.

Fukase, E. and W. Martin (2020). Economic growth, convergence, and world food demand and supply. *World Development*, *132*, 104954.

Jahan, H.; M.W. Rahman; M.S. Islam; A. Rezwan-Al-Rami; M.M.U.J. Tuhin and M.E. Hossain (2022). Adoption of agroforestry practices in Bangladesh as a climate change mitigation option: Investment, drivers, and SWOT analysis perspectives. Environmental Challenges, 7, 100509.

Jara-Rojas, R.; S. Russy; L. Roco; D. Fleming-Muñoz and A. Engler (2020). Factors affecting the adoption of agroforestry practices: insights from silvopastoral systems of Colombia. *Forests*, **11**(6): 648.

Hossain, M.E.; M.S. Islam; M.H.K. Sujan; M.F.U.J. Tuhin and F.V. Bekun (2022). Towards a clean production by exploring the nexus between agricultural ecosystem and environmental degradation using novel dynamic ARDL simulations approach. *Environmental Science and Pollution Research*, 1-17. DOI:10.1007/s11356-022-19565-5.

Kusters, K.; M.R. Perez; H.D. Foresta; T. Dietz; M.A.F. Ros-Tonen; B. Belcher; P. Manalu; A.A. Nawir and E. Wollenberg (2008). Will agroforests vanish? The case of Damar agroforest in Indonesia. *Human Ecology*, **36:** 357–370.

Meijer, S.S.; D. Catacutan; O.C. Ajayi; G.W. Sileshi and M. Nieuwenhuis (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. *International Journal of Agricultural Sustainability*, **13**(1): 40-54.

Mfitumukiza, D.; B. Barasa and A. Ingrid (2017). Determinants of agroforestry adoption as an adaptation means to drought among smallholder farmers in Nakasongola District, Central Uganda. *African Journal of Agricultural Research*, **12(**23): 2024-2035.

Nath, T.K.; M. Jashimuddin; K. Hasan; M. Shahjahan and J. Pretty (2016). The sustainable intensification of agroforestry in shifting cultivation areas of Bangladesh. *Agroforestry Systems*, **90**(3): 405-416.

Noman, M.A.A.; M.C. Bain; F. Ahmed; M.O.R. Sahel; M.A.Wadud and G.M.M. Rahman (2018). Interaction effect of mahogany tree on the yield performance of rice under agri-silvicultural system. *Journal of Agroforestry and Environment*, **12**(1): 19-23.

Oduniyi, O.S. and S.S. Tekana (2019). Adoption of agroforestry practices and climate change mitigation strategies in North West province of South Africa. *International Journal of Climate Change Strategies and Management*, 11(5):716-729. https://doi.org/10.1108/IJCCSM-02-2019-0009

Pretty J. and Z.P. Bharucha (2014). Sustainable intensification in agricultural systems. *Annals of Botany*, **114**(8): 1571-1596.

Rahman, M.S.; J. Rahman; M. Saifullah; K.N.A. Jewel and M. Yasmine (2021). Exploring improved agroforestry practiced farmer's socio-demographic characteristics and their livelihood in selective charlands of Bangladesh. Social Values and Society (SVS), **3**(2): 54-57.

Rahman, S.A.; M.H. Imam; D.J. Snelder and T. Sunderland (2012). Agroforestry for livelihood security in Agrarian landscapes of the Padma floodplain in Bangladesh. *Small-scale Forestry*, **11**(4): 529-538.

Rasul, G. and G.B. Thapa (2006). Financial and economic suitability of agroforestry as an alternative to shifting cultivation: The case of the Chittagong Hill Tracts, Bangladesh. *Agricultural Systems*, **91**(1-2): 29-50.

Saha, S.; A. Sharmin; R. Biswas and M. Ashaduzzaman (2018). Farmers' Perception and Adoption of Agroforestry Practices in Faridpur District of Bangladesh. *International Journal of Environment, Agriculture and Biotechnology*, **3**(6):1987-1994.

Sanchez, P.A. and M.S. Swaminathan (2005). Cutting world hunger in half. *Science*, **307** (5708): 357–359.

Sharmin, A. and S.A. Rabbi (2016). Assessment of farmers' perception of agroforestry practices in Jhenaidah district of Bangladesh. *Journal of Agriculture and Ecology Research International*, **6**(4): 1-10.

Slingo, J.M.; A.J. Challino; B.J. Hoskins and T.R. Wheeler (2005). Introduction: food crops in a changing climate. *Philosophical Transactions of The Royal Society B Biological Sciences*, **360**(1463): 1983-1989. DOI:10.1098/rstb.2005.1755.

Tsonkova, P.; J. Mirck; C. Böhm and B. Fütz (2018). Addressing farmer-perceptions and legal constraints to promote agroforestry in Germany. *Agroforestry Systems*, **92**(4): 1091-1103.

United Nations. (2019). World Population Prospects: The 2019 Revision. New York: United Nations.

van Dijk, M.; T. Morley; M.L. Rau and Y. Saghai (2021). A meta-analysis of projected global food demand and population at risk of hunger for the period 2010-2050. *Nature Food*, **2**(7): 494-501.

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