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Impacts of agroforestry on agricultural productivity, ecosystem services, and human well-being in terrace ecosystem of Bangladesh

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ABSTRACT

A benchmark survey was conducted on sixty respondents in four villages under Belabo Upazila of Narsingdi district in terrace ecosystem of Bangladesh to get primary information from the farmers on existing agroforestry practices from August 2011 to October 2011. Different agroforestry practices have been practicing since long time. Most of the respondent farmers were motivated by neighbors. The farmers were getting good prices of their products but they were not getting desired yields from agroforestry systems. Disease and insect infestation, lack of modern technologies and their proper management were mostly responsible for poor yield. Turmeric, ginger, eggplant and okra were reported as suitable understory crops for agroforestry systems. Jackfruit based agroforestry systems were identified as dominant one and other beneficial production systems where various fruit tree based such as latkan and lemon. Most of the respondents, however, agreed that agroforestry could improve crop environment and soil health. Meanwhile, lack of availability of irrigation was found a major barrier. Woman participation in agroforestry systems was not remarkable. Training and appropriate technologies were seemed to be helpful for the farmers to improve systems, productivity and income in the study areas. Practicing agroforestry systems by the farmers was increased with higher level of education, training, annual income, desired yield, soil fertility and environmental benefit. Socio-economic characteristics of the respondents have profound influence on their agroforestry systems.

INTRODUCTION

Bangladesh is one of the most densely populated countries in the world where 1056 persons are living per square kilometer (BBS, 2014). The per capita land area is decreasing at an alarming rate due to increasing population (Hossain and Bari, 1996).This availability of land has been declined from 0.19 ha in 1961 to 0.05 ha in 2013 (World Bank) and now the country is claimed to have the lowest per capita arable land of 0.02 ha. In Bangladesh, the need for maintaining the population-food nutrition balance can hardly be overemphasized. Agriculture land is the most basic resource in Bangladesh-the main component for crop production. The current land/person ratio is very unfavorable, and there is little or no scope of expanding the land resource base. The agroforestry systems in Bangladesh are an integrated production system (Khaleque,

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1987) and a stable ecosystem that maintains the diversity of life as well as the biological wealth. It is the main source of food, fruits, vegetables; timber and fuel wood for the household and is a reliable source of household income (Nair, 1993). In this study we mainly tried to investigate the present condition of local farmers, their status, and income and future motives in terrace ecosystem of Bangladesh. In fact, in Bangladesh, most of the native fruits, vegetables, timber and fuel wood come from the homesteads or marginal lands attached to or near homestead. It has been estimated that 3 million ha of the homestead provided 80% of fruits and 85% of fuel wood, as well as timber (Rahim, 1997). Still there is very much shortage of food, nutrients and other forest products. There is absolutely no scope to increase land under forestry/agriculture to fulfill national demands. Since the space limitation in the homestead, multi-storied cropping especially agroforestry systems should be encouraged which can produce more economic return per unit area (Ahmed and Ali, 2003). The utilization of land should be done in such a way that also maintains the ecological balance in the region (Mallik and Ruhul, 2001). The objective of the study was to find out primary information from the farmers on existing agroforestry practices in terrace ecosystem of Bangladesh.

METHODOLOGY

Location and duration

Figure 1: Triangular yellow arrow in Map showing Belabo upazila under Narsingdi District

Bangladesh is located between 20°34'-26°3' N; and 88°01'-92°41' E. It is bordered by the Bay of Bengal on the South and by India on all other sides along with small part of Myanmar. The experimental site is situated at about 56 km and 7 km away from the capital city Dhaka and Narsingdi town, respectively. The study site is located at the 23º 29´ North latitude and 90º10´ East longitude with a mean elevation of 8.5 m above sea level (FAO/UNDP, 1988) (Figure 1).

Benchmark Survey

Benchmark survey was conducted from August 2011 to October 2011 to know the demography, socio-economic conditions and livelihood activities of the respondents. Moreover, detail production practices for both tree and crop components, growth and yield of crops and tree species, environmental changes, cost of all inputs and outputs were also recorded using the same questionnaire. A pre-tested and structured questionnaire was used to collect data from the randomly selected 60 farmers.

Preparation of questionnaire

The questionnaire was designed to obtain relevant information according to the objectives of the study. The questionnaire was pre-tested with limited respondents. On the basis of the pre-tested questionnaire, necessary suggestions, modifications, addition and alterations were made to improve the validity and applicability of the questionnaire. The group discussion was organized to identify common opinions of the respondents regarding required data on various aspects of livelihood activities and socioeconomic conditions.

Sampling technique

Considering the limitation regarding time and money, a simple random sampling technique was followed. Four villages under Belabo upazila under Narsingdi district were selected. From the selected four villages, 60 respondents were selected comprising 15 from each of Kumartek, Moishertek, Abdulanagar and Lakhpur villages (Kothari, 2004).

Data collection

Direct interview method was followed with the respondents in data collection. The researcher himself collected the necessary information during the study period through questionnaire. Appointments with the respondents were made in advance through Field Assistant. This helped the researcher to have a friendly orientation with the respondents. Before interviewing the respondents, a brief introduction of the aims and objectives of the study were explained to each respondent. When they were convinced that the study was purely academic and had no adverse effect on them, then they provided their full co-operation to the researcher. The researcher took necessary care to establish rapport with the respondents so that they did not feel any hesitation. Whenever any respondent felt any difficulty in understanding question, the researcher took utmost care to explain and clarify them properly. After completion of each interview, the schedule was checked and verified to be sure that the answers were correct.

Processing and tabulation of data

After collection of data, the first step was to look over the data of each and every interview schedule whether every question was replied properly or not. All the collected benchmark survey data were summarized, scrutinized, coded and recoded in Statistical Package for Social Science (SPSS) computer software.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

The socio-economic characteristics of the respondent's included age, family size, occupation, years of schooling towards existing agroforestry systems and practices. These are described in Table 1.

Age

The age of the respondents ranged from 18 to 64 years with an average of 46.08 and standard deviation of 11.45. Based on their age, the respondents were classified into three categories as young (less than 35 years), middle aged (35-50 years) and old aged (over 50 years) as suggested by Haider (2010). Number and percentage distribution of farmers according to their age group has been shown in the Table 1. It is revealed that the majority of the respondents were in the middle age category (48.33%). This finding is adequate to the national statistics indicating that the selected respondents were typical respondents of the country (MoEF, 2001).

Family size

Family size was assessed on the basis of total number of members in a family. It ranged from 02 to 11 members with an average of 4.93 members per family which was very much related to the current average family size of Bangladesh. The average household size in Bangladesh was 4.66 (HIES, 2010) and 4.35 (BBS, 2012) persons per family in 2004 and 2011, respectively (BBS, 2011). The family size was categorized into three groups, i.e., small family (family member≤4), medium family (family member 5-8) and large family (family member>8). The highest proportion of the respondents had medium family size (50%) whereas, 41.66 and 8.34% of the respondents had small and large family size, respectively (Table 1). Data presented in the Table 1indicated that 50% of the respondents were in medium size family which was also a representative of typical family size in Bangladesh. In Bangladesh it is very common to live together with parents and with brothers and sisters and sometime with relatives (Joint family) (MoEF, 2001). It was noted that the percentage of joint families was higher in large farm categories. This might be one of the reasons for larger family size in large farm categories.

Occupation

In rural area of Bangladesh maximum number of populations is either involved in agriculture. A small portion of the population is engaged in business while some earn their daily life from service in the local area or elsewhere. The occupations of the respondents were categorized into four groups (Table 1). Among the four occupations of the respondent's agriculture (62.67%) was the major occupation of the total

respondents and was followed by service (18.33%), business (15%) and others (4%).

Educational level

The level of education of the respondents were categorized into four groups i.e., illiterate (no schooling), primary level (class I-V), secondary level (class VI-X) and above secondary level (college and university). The level of education of the respondents ranged from illiterate (no schooling) to above secondary with the mean and the standard deviation of 0.92 and 0.83 respectively. About 46.67% of the respondents had primary level education, whereas, 15 and 5% of the respondents had secondary and above secondary level education, respectively. However, 33.33% of the respondents had no education. The level of education of the respondents is shown in Table 1. This observation is also in conformity with national average of education of Bangladesh (BBS, 2003 and MoE, 2004).

Table 1: Distribution of the respondent according to their socio-economic characteristics

Characters	Unit	Categories	Respondents' opinion			
			Frequency	Percent	Mean	SD
Age	Actual year	Young aged (<35)	9	15	46.08(±0.06)	11.45
		Middle aged (35-50)	29	48.33		
		Old aged (>50)	22	36.67		
		Total	60	100		
Family size	Number	Small family (≤4)	25	41.66	4.93(±0.03)	2.47
		Medium family (5-8)	30	50		
		Large family (>8)	5	8.34		
		Total	60	100		
Occupation	Number	Agriculture	37	61.67	1.62(±0.02)	0.90
		Service	9	15		
		Business	11	18.33		
		Others	3	5		
		Total	60	100		
Education	Year of schooling	No schooling	20	33.33	0.92(±0.02)	0.83
		Primary (1-5)	28	46.67		
		Secondary (6-10)	9	15		
		Above secondary (>10)	3	5		
		Total	60	100		

Land use and Socio-economics

The current livelihood activities and socio-economic status of the respondents in the study area have been described below.

Land use

Each farmer was using their land in different ways. Five common landuse patterns were found in the study area i.e., agriculture, agroforestry, homestead, gardening and others.Among thosepractices, how every individual farmer was using his/her land was given in the Figure 2. Gardening was the significantly dominant (1.22 ha) followed by agriculture (0.36 ha), agroforestry (0.22 ha), homestead (0.13 ha) and others (0.028 ha).

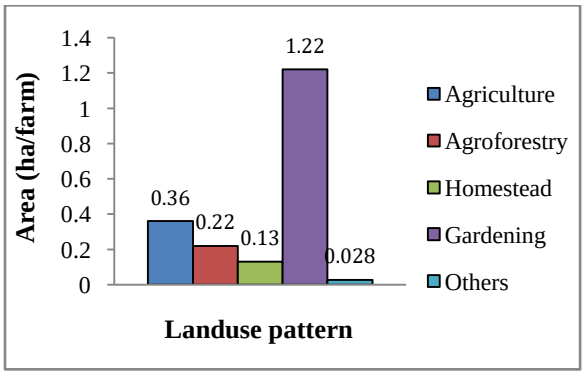

Figure 2: Landuse pattern in the study area

The data presented in figure 2 indicated that agroforestry is being practiced in small scale, but the land is not being used for crop production. The lands might be a good production unit if crops are grown in association with the trees.

Land resource utilization for cropping

Figure 3 indicated the pattern of land resource utilization for crop production in the study area. It was noted that the respondents used their land resources throughout the year with some remarkable variations among the seasons. Rabi was the most important cropping season (78.73%) followed by Kharif-1 (48.16%) and Kharif-2 (74.58%). It was found that irrigation water was a big problem particularly during dry season. In rabi season, risk of natural calamities is less; weed, disease and insect infestation are also less in the winter season.

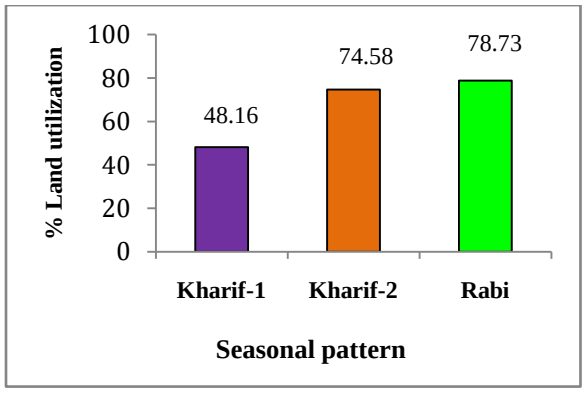

Figure 3: Seasonal pattern of land resource utilization crop production in the study area

Training received on agroforestry or crop production

Training refers to organized activity aimed at improving information and/or instructions to improve the recipients' performance or to help him or her attain a required level of knowledge or skill. The respondents were asked whether they got training on agroforestry/crop production to increase knowledge. The findings revealed that most of the respondents opined that they had training while the respondent, which was not mentionable, did not get any training in the study area (Figure 4).

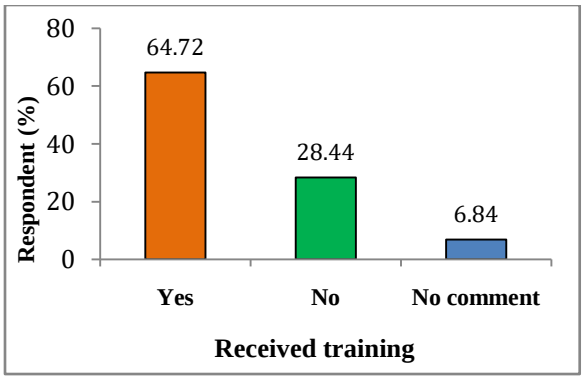

Figure 4: Training received on agroforestry/ crop production

Woman participation in agricultural production system

The study revealed that about 78.47% of women was participating in production system with male in the study area (Figure. 5). Since farming was found profitable in the study area, both men and women have been actively participating in various production system that might have ensured high production and income generation at household level.

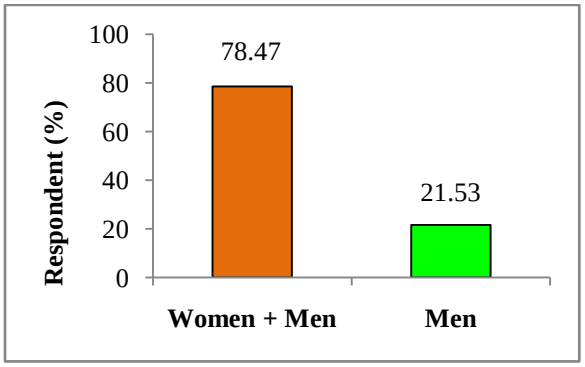

Figure 5: Women participation in agriculture production systems in study area

Marketing channel

Marketing channel of farm comodities across the study area was different (Figure 6). Most of the respondents used to sell their products from farm (61%) followed by bazar (28%) and bazar + farm (11%) in the study area. Poor communication facilities lead the farmers to sell their products from farm.

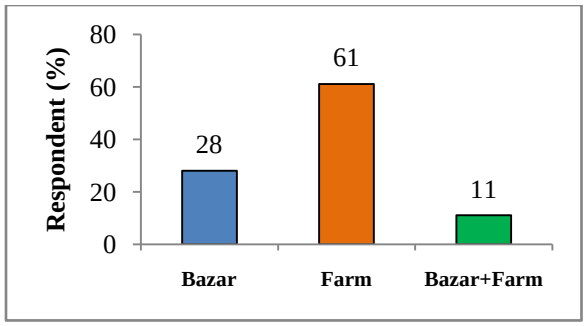

Figure 6: Distribution of the respondents according to marketing channel of their farm commodities

Price level

More than 64.55% respondents opined that they were getting desired price of their products, while more than 27.68% respondent did not get desired price and 7.77% of the respondent had no comment about the price level in the study area (Figure 7). However, the study area is one of the high potential areas for vegetable production in Bangladesh. Due to good transportation facility with Dhaka and Narsingdi cities, the price was quite better than other potentials areas. Although many farmers were satisfied with the price of the products but they were not satisfied with their production level.

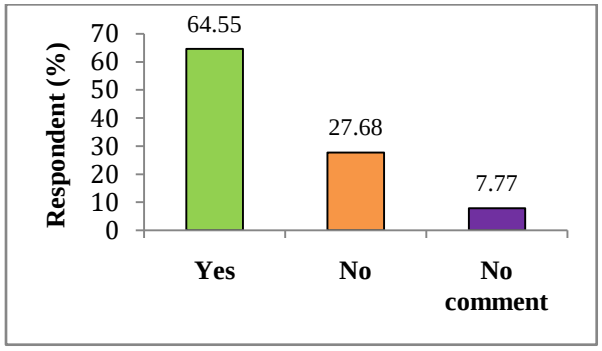

Figure 7: Distribution of the respondents according to getting desired price of their farm commodities in the study area

Estimation source of income

Annual income of the respondents varied remarkably in the the study area (Table 2). Among different income sources, service, buisness, agricultural crop, fruit tree, forest tree, livestock and poulty and agroforestry contributed a lot to the annual income of the respondents. In the study area, fruit trees played a vital role in annual income, which was Tk 144175 followed by service (Tk 134444), buisness (Tk 128363), agricultural crops (Tk 53223), forest tree (Tk 10000), livestock and poulty (Tk 18150) and others (Tk 27608), respectively. However, income from agroforestry (Tk 15106) was not at the desirable level which might be due to low management parctices and lack of appropriate technologies.

Table 2: Source of annual income (Tk) of the respondent in study area

Sl. No.	Source	Income (Tk)	Rank
1	Fruit tree	144175	1
2	Service	134444	2
3	Business	128363	3
4	Agricultural crop	53233	4
5	Forest tree	10000	5
6	Livestock and poultry	18150	6
7	Others	27608	7
8	Agroforestry	15106	8

Dominant agroforestry system

Agroforestry systems widely varied in the study area (Table 3). Jackfruit based system was found dominant in the study area, where Jackfruit+Eggplant was the most frequent (52%) practice one followed by Jackfruit+Burmese grape+Eggplant (16%), Jackfruit+Turmeric (12%), Jackfruit+Ginger (12%) and Jackfruit+Cucumber (8%), respectively. Table 3 also revealed that multistoried agroforestry systems were widely found in the study area.

Table 3: Dominant agroforestry systems in the study area

Sl. No.	**Existing agroforestry systems**	**Respondent (%)**	**Rank**
1	Jackfruit+Eggplant	52	1
2	Jackfruit+Burmese grape+Eggplant	16	2
3	Jackfruit+Turmeric	12	3
4	Jackfruit+Ginger	12	3
5	Jackfruit+Cucumber	8	4

Motivation on adopting agroforestry

Respondents were asked about first timemotivation in agroforestry and it was observed that most of the respondents (91%) were convinced by neighbour, while 9% respondents were self motivated in the study area (Figure 8).

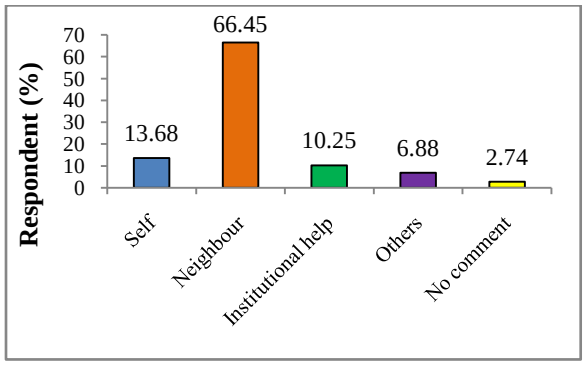

Figure 8: Distribution of the respondent according to motivation in practicing agroforestry in the study area

Desired yield from agroforestry

The respondents who were practicing agroforestry opined differently on getting desired yield from the production system (Figure 9). Most of the respondents (52.45%) reported that they were not getting desired crop yield as because they had been practicing mostly in a traditional way and did not manage well. However, 36.28% of the respondents opined that they were getting desired crop yield because of practicing agroforestry systematically with new fruit tree species.

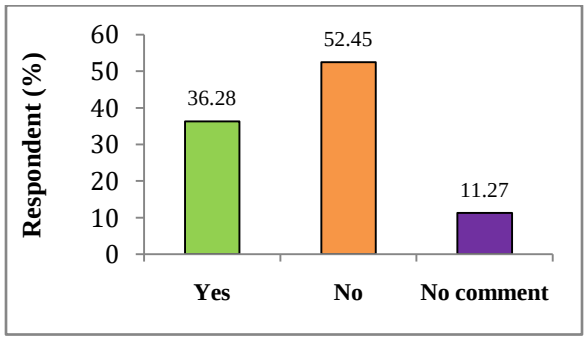

Figure 9: Distribution of the respondent in getting desired yield from agroforestry in study site

Reason for not getting desired yield

A number of reasons had been identified behind not getting desired yield (Table 4). Among those, lack of improved management practices (53.33%) was the major reason followed by infestation of insect and diseases (40%), lack of modern technology (38.33%), fruit dropping (31.66%), lack of irrigation facilities (28.33%), lack of judicious use of pesticides (12.34%) and vertebrate pests (5%) for not getting desired yield.

Table 4: Reason for not getting desired yield from agroforestry in study areas opined by respondent

Reason	Respondent (%)	Rank
Lack of improved management practices	53.33	1
Infestation of insects and diseases	40.00	2
Lack of modern technology	38.33	3
Fruit dropping	31.66	4
Lack of good variety	28.33	5
Lack of irrigation facilities	28.33	5
Lack of judicious use of pesticides	12.34	6
Vertebrate pests	5.00	7

Suitable crop species

Most of the respondents opined that turmeric (76.66%) was the most suitable species in agroforestry system.

Table 5. Suitable crops for agroforestry systems in study areas

Crop	Respondent (%)	Rank
Turmeric	76.66	1
Egg plant	70.00	2
Ginger	58.33	3
Aroid	41.66	4
Papaya	20.00	5
Bottle gourd	18.33	6
Chili	16.66	7
Bitter gourd	11.66	8
Yard long bean	8.33	9
Lemon	8.33	9
Okra	6.66	10

Egg plant under Jackfruit trees was also widely found as most profitable crop, next to turmeric by 70% respondents, while ginger (58.33%), aroids (41.66%), papaya (20%), bottle gourd (18.33%), chili (16.66%), bitter gourd (11.66%), yard long bean (8.33%), lemon (8.33%) and okra (6.66%) were also reported as suitable crops (Table 5)(Michon et al., 1983).

Overall yield advantage

In the study area, mostly Jackfruit based agroforestry system was identified as good system where farmers were getting benefit from this system. Moreover, some multistoried agroforestry systems were identified as profitable systems in the study area. Among the multistoried systems, Jackfruit+Burmese grape+Turmeric was the most beneficial system (40%) followed by Jackfruit+Burmese grape+Eggplant (35%), Jackfruit+Ginger (34%), Jackfruit+Turmeric (33.57%), Jackfruit+Eggplant (31.36%), Jackfruit+Burmese grape+Aroid (31.33%), Burmese grape+Ginger (25%) and Jackfruit+Gourd (20%). Therefore, oeverall benefit was realtively higher in Jackfruit+Burmese grape+Turmeric compared to other multistoried agroforestry systems (Table 6).

Table 6: Overall yield advantage from agroforestry pactice in study site

Agroforestry practice	Overall benefit (%)	Rank
Jackfruit+Burmese grape+Turmeric	40.00	1
Jackfruit+Burmese grape+Eggplant	35.00	2
Jackfruit+Ginger	34.00	3
Jackfruit+Turmeric	33.57	4
Jackfruit+Eggplant	31.36	5
Jackfruit+Burmese grape+Aroid	31.33	6
Burmese grape+Ginger	25.00	7
Jackfruit+Gourd	20.00	8

Management practice

In the study area, most of the respondents (83.12%) opined that they did not do much management practices, while 10.92% ofthe respondents opined that they used to do intensive management practice in agroforestry system (Figure 10). This might be due to lack of training.

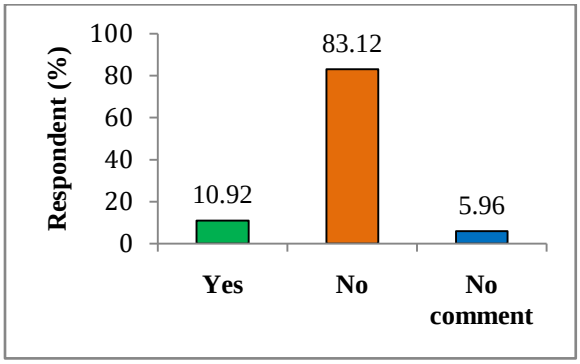

Figure 10: Respondentsopinion on management practcie followed in agroforestry systems in study site

Soil fertility improvement through aroforestry system

Improvement of soil fertility is one of the major objectives of the any agroforestry practices. It's not so easy task to improve the soil health. Farmers of the study area have been in agroforestry practice since long time. So, they could realize the improvement of soil fertility through this practice. Most of the respondents (64.72%) opined that soil fertility improvement and reduction of soil erosion were the main aspects of soil conservation through practicing agroforestry by addition of organic matter (Figure 11). Thus, agroforestry help increase the soil fertility.

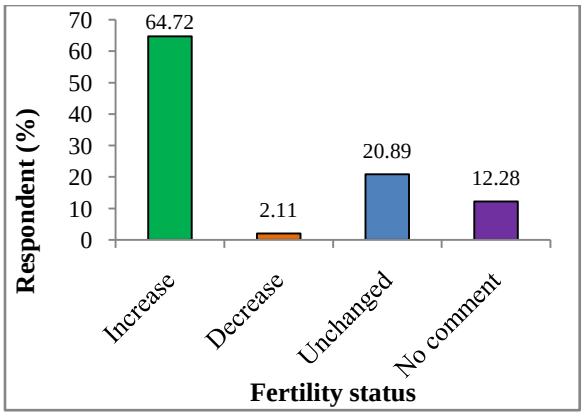

Figure 11: Distribution of the respondents according to improvement of soil fertility in agroforestry practices in the study area

Environmental benefit

It is widely believed that agroforestry has the potentiality to retain good environment as service function. Likewise, a significant number of respondents (82.69%) opined that they were getting environmental benefits from agroforestry practices. Soil moisture availability to the under-storied crops was the major benefit of the agroforestry, while sufficient rainfall, required less irrigation, shade during high sunlight and cool weather were other benefits. On the other hand, 10.76% of the respondents did not have experience any environmental benefit from agroforestry practices while 6.55% of the respondent had no comment (Figure 12).

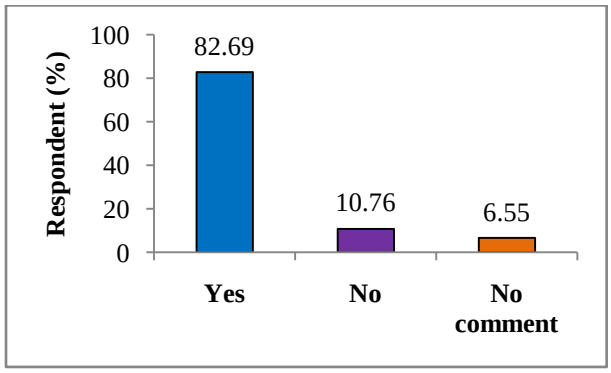

Figure 12: Distribution of the respondents according to getting environmental benefit from agroforestry practices in the study area

Assistance need

Respondents identified some issues where they need assistance to increase the productivity of agroforestry system. Assistance in providing training (60%) was the most important issue as opined by the respondents followed by supply of quality seed and pesticide (41.67%), quality planting materials (40%), technology (35%), irrigation facility (28.33%), financial support (22%) and agricultural inputs (15%) (Table 7).

Table 7: Assistance need to increase the productivity of agroforestry practices in study area

Sector	Respondent (%)	Rank
Training	60.00	1
Pesticide	41.67	2
Quality seed	41.67	2
Quality planting materials	40.00	3
Technology	35.00	4
Irrigation	28.33	5
Financial	22.00	6
Agricultural inputs	15.00	7
Soil test	10.00	8

Advantages of agroforestry

Advantages of agroforestry were expressed by the respondents in the study area that are presented in the Table 8. Year round production (65%) and higher income (60%) were two major advantages, while supply of fuel (51.67%), less fertilizer requirement (8.34%) and increase soil fertility (3.34%) were some other advantages.

Table 8: Advantages of practicing agroforestry systems in study area

Advantage	Respondent (%)	Rank
Year-round production	65.00	1
Higher income	60.00	2
Fuel supply	51.67	3
Less fertilizer required	8.34	4
Increase soil fertility	3.34	5

Socio-economic characteristics of the respondent and adoption of practicing agroforestry practices

Age, occupation and woman participation of the respondents were not important indicator concerning the adoption of practicing agroforestry practices (Table 9)**.** Age was, however, found positive and significant, which was consistent with the findings of (Etoundi and Dia, 2008 and Nwakor et al., 2011). Positive relation of occupation with practicing agroforestry practices (Amin and Islam, 2009). Level of education and adoption of practicing agroforestry practices were significantly and positively correlated. That is, the educated respondents are more interested in adoption of practicing agroforestry practices. This finding is in harmony with the report of Amin and Islam, 2009 and Hoque et al., 2010. Training of the respondent had significant relationship with their adoption of practicing agroforestry practices which also supported by Hoque et al., 2010. Annual income of the respondent had also significant positive relationship with the adoption of practicing agroforestry practices i.e., the higher is the annual income of the respondents, the more they adopted with agroforestry practices. It implied that with increased income, respondents were able to procure inputs for agroforestry practices so that they invested more which brought for them higher income. Desired yield had significant positive relationship with adoption of agroforestry practices. It is obvious that respondents might have changed the attitude and thus they become interested to adopt agroforestry practices. This finding is very consistent with several studies carried out by Amin and Islam, 2009 and Hoque et al., 2010. Other variables like soil fertility and environmental benefit on practicing agroforestry practices were as well positively correlated with adoption of practicing agroforestry practices (Rahm and Huffman, 1984).

Table 9: Relationships between socio-economic profile of the respondents and their adoption of practicing agroforestry practices

Independent variable	Dependent variable	Co-efficient of correlation (r)
Age of the respondents	Adoption of practicing agroforestry practices	0.064
Family size		0.263(**)
Occupation		0.055
Respondents' education		0.286(**)
Training		0.229(**)
Annual income		0.181(**)
Woman participation		0.021
Desired yield		0.307(**)
Soil fertility		0.852(**)
Environmental benefit		0.678(**)

CONCLUSION

The amount of information generated is so large and complex that researchers need more sophisticated techniques to analyze the data and utilize them meaningfully. The modern technologies of agroforestry systems and training supports to develop the productivity were almost not available. Increased agroforestry systems and their appropriate management including intercropping practices should be the strategy for enhancing smart agriculture of the study area in order to meet basic needs of its people, soil health and maintain environmental balance.To get fruits, fuel wood, timber and various agricultural products as well as to bring back equilibrium in the ecosystem, establishment of multi-layered cropping systems in the orchard is inevitable. The agroforestry systems should be applied in

the orchards of jackfruit in central terrace ecosystem of Bangladesh. In spite of the immense scope and prospects of the agroforestry systems no systematic program has been undertaken so far to improve the productivity of the farmers. The agroforestry systems can be improved by proper care management practice, more research performance, cooperative and extension services etc., and replace low economic value crops by high economic value crops. This will ensure sustainable production for the poor farmers of Bangladesh. Efforts should be made to make the rural farmers aware of the appropriate planning and management of the homesteads and to provide them with necessary training and other technical supports for these purposes for more income generating activities. The efforts should be made to identify different shade tolerant vegetables and to motivate and train the farmers to increase the vegetables production of the study area. Women work efficiency should be increased by training, education and extension supports since they are mainly involved in agriculture production system. To improve the socio-economic conditions of the household's productivity, designing of new program to develop the agroforestry production system in accordance with the farmer's needs, resource base, goals and preferences, and bio-physical setting is an urgent issue. That program can only lead to viable production systems towards sustainable livelihood in the coming future. Increased agroforestry systems in fallow area especially in the central terrace ecosystem should be the strategy for enhancing the smart agriculture of the country in order to meet demand for food, fuel wood and timber for the households and fodder for the livestock, as well as to maintain the sustainability of production system.

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REFERENCES

Ahmed M and Ali MH (2003). Agroforestry-environmental linkages and different tree species in homegarden. Lecture note prepared for the Agroforestry Training Workshop held during BARC, Dhaka; pp. 51-8.

Amin MR and Islam MR (2009). Adoption of recommended potato production practices by the farmers in some selected areas of Naogaon District. Bangladesh Journal of Extension Education, 21(1 &2): 125-132.

BBS (2011). Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (2012). Population and Housing Census 2011: Socio-Economic and Demographic Report National Series, Volume-4, Bangladesh Bureau of Statistics, Statistics And Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (2014). Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Etoundi SMN and Dia BK (2008). Determinants of the adoption of improved varieties of maize in Cameroon: Case of CMS 8704. Proceedings of the African Economic Conference 2008, 97-413.

FAO/ UNDP (1988). Agro-ecological regions of Bangladesh. FAO/UNDP, Rome, Italy. PP. 570.

MoEF (Ministry of Environment and Forestry), Government of Bangladesh. 2001. Prospectus of Traditional homegarden Agroforestry in Bangladesh at a momentary look. Dhaka, Bangladesh.

MoE (Ministry of Education), Government of Bangladesh. 2004. Statistical Pocketbook Bangladesh 2003. Bangladesh. Bureau of Statistics, Dhaka, Bangladesh.

Haider M (2010). Integrated Pest Management Club for Forecasting Farmers' Empowerment in Rice Production. PhD.(Ag. Ext and Rd.)Dissertation, Department of Agricultural Extension and Rural Development, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.

HIES (2010). Household Income and Expenditure Survey Report 2010**,** Chapter-II, Household and Population Characteristics, Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh.

Hoque MZ, Haque ME, Afrad MSI and Hossain MA (2010). Adoption of farming technology by the

charland farmers. Bangladesh Journal of Extension Education, 22 (1 &2):49-55.

Hossain SMA and Bari MN (1996). Agroforestry farming System. In: Agroforestry in Bangladesh. PP. 22-29.

Khaleque K (1987). Homestead forestry practices in Bangladesh. Agroforestry for rural needs. Proceedings of the workshop of the IUFRO project group, India 1987.

Kothari CR (2004). Research Methodology. Methods & Techniques (First Edition), 4835/24Ansari Road, Daryaganj, New Delhi 110 002.

Mallik AAS and Ruhul A (2001). Prospect of agroforestry in Bangladesh and Effective Management Systems in the RDRS Area of Northern Bangladesh. In: Hsiung W, Chandler PF, Eds. Agroforestry, Research and Practice. China Forestry Publishing House, Beijing, P.R. China.

Michon G, Bompard J, Hecketsweiler P, Ducatillion C (1983). Tropical forest architectural analysis as applied to agroforests in the humid tropic: The example of traditional village-agroforests in West Java. Agroforestry System, 1: 117-29.

Nair PKR (1993). An introduction of homegarden agroforestry. ICRAF, Nairobi; p. 85.

Nwakor FN, Ifenkwe GE, Okoye BC, Nummadu FN, Anyaegbunam HN, Ekedo TO and Onyia CE (2011). Socio-Economic Factors Affecting Adoption of Improved Cassava Varieties among Farmers in Abia State. Journal of Agriculture and Social Research, 11(1): 63-71.

Rahim MA (1997). Horticultural crops and agroforestry in Bangladesh. Proc. Workshop on Agroforestry. GTI, BAU, Mymenshingh; pp. 83-90.

Rahm MR and Huffman WE (1984). The adoption of reduced tillage: The role of man, capital and other variables. American Journal of Agricultural Economics, 66(4): 405-413.