IMPACT OF AGROFORESTRY SYSTEMS ON TREE SPECIES DIVERSITY AND FARMERS LIVELIHOOD OF BHOLA SADAR AND DAULAT KHAN UPAZILA IN BHOLA DISTRICT

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CERTIFICATE

This is to certify that the thesis entitled **"IMPACT OF AGROFORESTRY SYSTEMS ON TREE SPECIES DIVERSITY AND FARMERS LIVELIHOOD OF BHOLA SADAR AND DAULAT KHAN UPAZILA IN BHOLA DISTRICT"** submitted to the Department of Agroforestry and Environmental Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **AGROFORESTRY AND ENVIRONMENTAL SCIENCE**, embodies the result of a piece of bonafide research work carried out by **MD. MAHMUDUR RAHMAN**, Registration No. **15-06599** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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Dedicated

To My

Beloved Parents

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IMPACT OF AGROFORESTRY SYSTEMS ON TREE SPECIES DIVERSITY AND FARMERS LIVELIHOOD OF BHOLA SADAR AND DAULAT KHAN UPAZILA IN BHOLA DISTRICT

ABSTRACT

The purpose of this study was to assess the impact of agroforestry system on tree species diversity and farmers livelihood of Bhola sadar and Daulat Khan upazila in Bhola district. Assessment was done by approach of purposive random sampling. Information concentrated from an accumulation of 64 households ranging from marginal, small, medium and large categories. A total of 3032 trees representing 19 families in homestead, 671 trees with 12 families in crop land and 479 trees with 7 families in road side were identified. In the study area, fruit/food (25.58%), fuel wood (25.00%), timber (22.09%), fodder (9.30%), medicinal (8.14%), fence (4.65%) and others species (3.49%) were found in homestead. On the other hand, in crop land, mainly fruit/food species (22.22%), timber species (25.93%) and fuel wood tree species (22.22%) were found. In road side, mainly timber species (32.50%), fuel wood tree species (27.50%) and fruit/food species (15.00%) were found. Considering the abundance of tree species in the study area, the highest percentage of tree species abundance was found for mango (11.48%) followed by coconut (9.50%) and rain tree (9.10%) in homestead. Again, the highest percentage of betelnut (15.20%) followed by jackfruit (11.92%) and mango (10.73%) were found in crop land. Similarly, the highest percentage of koroi (17.54%) followed by raintree (13.99%) and mango (12.73%) were found in road side. Shannon Wiener index (H) was used to evaluate the tree diversity and the evaluation showed that tree species diversity in homestead was 1.314 thereafter 0.546 was in crop land and 0.417 in road side. Farm size, homestead size, total annual income, livelihood status of the farmers and changes of livelihood status of the farmers were significant with concerned variable in all agroforestry systems which had significant impact on livelihood status of the farmers. Among the three agroforestry systems studied, homestead agroforestry showed higher tree species diversity and facilitate better livelihood status of the farmers in the study area. The findings from this study have the potential to inform and enhance agroforestry programs, enabling the effective implementation of tree planting, initiatives tailored to diverse target populations within varying economic and environmental contexts.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
LSD	=	Least Significant Difference
m^2	=	Meter squares
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
%	=	Percentage
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Bangladesh, with its population of approximately 142.3 million people in a land area of 147,570 km^2, is known for its high population density (BBS, 2020). The country has a total area of 14.4 million hectares, with 13.62 million hectares dedicated to land and 0.78 million hectares occupied by rivers. Among the available land, 7.62 million hectares are cultivable, while forests cover approximately 2.5 million hectares (BBS, 2020). The majority of the population, about 70%, resides in rural areas, distributed across 25.35 million households in 87,316 villages (BBS, 2020). Homestead land, on the other hand, comprises only 808,254 hectares, accounting for roughly 10.63 percent of the total cultivable land, with an average of 0.03 hectares per household (BBS, 2020).

The practice of agroforestry systems including homestead, crop land and road side agroforestry offers a range of benefits which contributed to socioeconomic changes of farmers livelihood (Sanchez *et al*., 1997; Garrity *et al*., 2010; Tanga *et al*., 2014). In the Central Rift Valley of Bangladesh, farmers place considerable importance on tangible goods such as firewood, timber, and fruits, while also recognizing and valuing the multiple ecosystem services provided by trees (Iiyama *et al*., 2016).

Over the past few decades, the rapid growth of the human population has directly and indirectly contributed to the depletion of natural vegetation, leading to increased pressure on forests (homestead, crop land, road side etc.), particularly in developing countries (Alam and Masum, 2005). In Bangladesh, homestead, crop land and road side agroforestry play a crucial role to mitigate the country's timber, fuel wood, sawn and veneer logs and bamboo requirements, accounting for 70%, 90%, 48%, and almost 90% respectively (Uddin *et al*., 2002). The degradation of natural resources, particularly of agricultural and forest land, has become a global concern given the huge populations that rely on them for their sustenance (Baul *et al*., 2021). While agroforestry can be established to meet local needs while also protecting the environment, this method could possibly compete with regional food production. Agroforestry is one of the effective ways to resolve the trade-offs between economic, environmental and social benefits as it can simultaneously contribute to nutrition security, improved rural livelihoods and a variety of environmental benefits (Nair, 1990; Islam *et al*., 2013, Islam *et al*., 2015). For example, agroforestry systems have been demonstrated to facilitate improvements in the socioeconomic status of the farmers, increase farm productivity, enhance soil fertility, reduce erosion, improve water quality, conserve biodiversity, and sequester carbon help to mitigate global warming (Leakey, 2014; Schroth *et al*., 2004; Jose, 2009).

Agroforestry, the integration of tree, crop and vegetable on the same area of land is a promising production system for maximizing yield (Nair, 1990). Among different agroforestry systems, homestead, crop land and road side agroforestry are traditional, potential and promising in Bangladesh. Homestead is the *in situ* conservation sites of wide range of plant biodiversity (Mannan, 2000; Fernandes and Nair, 1990). Crop land agroforestry refers to the practice of integrating trees or woody plants with agricultural crops on dedicated crop land. It involves the deliberate combination of tree species and agricultural crops within the same land area, allowing for a symbiotic relationship between the two components (Nair, 2010). Roadside agroforestry, on the other hand, refers to the practice of integrating trees or woody plants with agricultural crops along roadsides or highways. It involves the deliberate planting and management of trees and crops in close proximity to roads or highways. Roadside agroforestry can provide numerous benefits, including erosion control, windbreaks, noise reduction, beautification, and additional income opportunities for farmers (Tanaka and Fujiwara, 2014). The homestead, crop land and road side agroforestry holds significant importance as a social and economic unit within rural households, providing a wide range of economic products and benefits (Shackleton *et al.*, 2008). Over the past millennium, the continuous cultivation and utilization of homegardens have played a crucial role in attaining sustainable livelihoods and self-sufficiency (Maroyi, 2009).

The forest is a crucial natural resource that plays a vital role in the socio-economic development and environmental balance of a country, typically requiring 25% forestland coverage of the total area. However, Bangladesh faces a significant challenge as it only has 9% forestland coverage as officially recorded, with trees covering a mere 5.5% of the total area, and this coverage is diminishing steadily. To counteract this concerning trend and address the deteriorating environmental conditions associated with traditional agriculture, the adoption of agroforestry practices becomes imperative. Within the homestead, crop land and road side agroforestry of Bangladesh, the presence of different trees and multipurpose use of trees serves as a source of livelihood for numerous farmers, boosting their income and providing a safety net during times of hardship and natural disasters (Hasan *et al.*, 2020).

For the present study, Bhola district was selected because of highly diversification in tree, crop and roadside agroforestry. Furthermore, incorporating intercropping different livelihood patterns of rural areas within the agroforestry framework can enhance farm production and productivity. So, the study was conducted with the following objectives:

1. To explore the contribution of farmers-led homestead, crop land and road side agroforestry practices to rural livelihood improvement based on tree species diversity and
2. To assess the relationship of the socioeconomic characters of the farmers and their tree species diversity in different agroforestry practices.

CHAPTER II

REVIEW OF LITERATURE

This chapter provides a brief review of past studies and opinions gathered from textbooks, journals, dissertations, reports, and other forms of publications, which are relevant to this investigation. The study focuses on the impact of agroforestry system on farmers livelihood in a specific region of Bangladesh.

2.1 Concepts of agroforestry

According to the World Agroforestry Center (2003), agroforestry is defined as a dynamic, ecological-based natural resource management system that involves integrating trees into farms and agricultural landscapes. This integration aims to diversify and sustain production, thereby increasing social, economic, and environmental benefits for land users at all levels.

Mesele Negash (2002) explains that within an agroforestry system, there are several key characteristics: (i) the presence of two or more species of plants (and/or animals), with at least one being a woody perennial, (ii) biological and economic interactions occur among the components of the system and (iii) the cycle of an agroforestry system spans more than one year.

Lakra and Sah (2008) stated that in homestead households manage a small garden around the house where they grow vegetables and fruits on the farmland. It was noted that, although home garden covered a small portion of the land, its output was very important for sustaining livelihood of the households. Homestead represents a land use system involving purposeful management of multipurpose trees and shrubs in intimate association with seasonal vegetables (Nair and Dagar, 1991).

In addition, Khalid and Bora (2000) emphasize that agroforestry goes beyond merely planting trees in fields or other areas. It serves as an effective land management system that ensures increased production within a balanced ecological environment. Agroforestry addresses the limitations of traditional agriculture, which often results in low output despite relatively high investment and leads to environmental degradation.

Saka *et al*. (1990) stated that in agroforestry systems there are both ecological and economical interactions between the different components. Agroforestry can provide a sound ecological basis for increase crop and animal productivity, more dependable economic returns and greater diversity in social benefits on sustained basis.

Crop land agroforestry refers to the practice of integrating trees or woody plants with agricultural crops on dedicated crop land. It involves the deliberate combination of tree species and agricultural crops within the same land area, allowing for a symbiotic relationship between the two components. In crop land agroforestry systems, trees are strategically planted alongside or within agricultural fields to provide multiple benefits such as improved soil health, enhanced biodiversity, increased nutrient cycling, and improved microclimate for crop growth. This integration can be achieved through various agroforestry practices, such as alley cropping, where crops are grown in alleys between rows of trees, or scattered tree plantings within the crop field (Nair, 2010).

Roadside agroforestry, refers to the practice of integrating trees or woody plants with agricultural crops along roadsides or highways. It involves the deliberate planting and management of trees and crops in close proximity to each other to create a productive and sustainable agroecosystem. Roadside agroforestry can provide multiple benefits, including enhanced soil conservation, improved water quality, increased biodiversity, and additional income streams for farmers (Prasad *et al*., 2014).

2.2 Livelihood of people based on agroforestry

Agroforestry is both economically and ecologically more complex form of land management than other forestry or agriculture systems. It plays a major role in providing both tangible and intangible benefits. Tangible benefits like employment generation and increased farm income and intangible one includes ecological restoration, which has been emphasized in respect of the various agroforestry systems. A worldwide initiative of agroforestry records indicate that it has potential for supplying multiple products, ecological restoration, and carbon sequestration and minimizing adverse climatic effects, maintenance of soil fertility ultimately etc. It has ability to conserve biodiversity by domesticating wild trees and shrubs, provide rural employment opportunities and increase farm income, utilizes wasteland and degraded land, aid industrial growth based on both agricultural and forestry raw materials, watershed stabilization etc. along with crop combination.

According to Mahato *et al.* (2019), the study conducted in the Ichak block of Hazaribagh district, Jharkhand, revealed that the majority of households (98.12%) were headed by males aged between 40-60 years. The respondents practiced various types of agroforestry on their farms, with 80 percent of them practicing agroforestry on farm sizes ranging from 0.5 to 1.0 acre. The predominant agroforestry practices in the area were Homestead (84.38%), Trees on Field Bunds (8.12%), and Silvipasture (7.50%). In terms of household income, 25.00% had a maximum monthly income ranging between Rs. 9001-11000, followed by 16.87% with income above Rs. 11000, and Rs.1001-3000.

Chavan *et al*. (2015) outlined the key features of the national agroforestry policy in India, which aims to implement successful ground-level schemes and overcome the challenges associated with agroforestry. The focus is not only on promoting agroforestry as an effective land-use system but also harnessing its potential for the economic development of the country.

Baig and Ehrenreich (2014) discovered that the concept of integrating land uses with forestry is not novel, as farmers have been practicing grazing forests and interplanting trees with crops for centuries, serving various purposes. However, their approach did not align with the modern recommended scientific practices.

In a study by Adedayo and Oluronke (2014), it was observed that there was a notable correlation between the educational qualifications and age of the respondents, as well as land ownership, and the adoption of agroforestry practices in the study area. However, no significant association was found between the size of the respondents' farms and the adoption of agroforestry practices in the same area.

Mustaq *et al*. (2012) while conducting study on selection of species for fuel wood used by the households in Samba district of Jammu and Kashmir in India revealed that State forests were the major source of fuel wood followed by their own farm. The species selection changes from village to village due to difference in personal choice and locality factors. *Acacia nilotica* and *Dalbergia sissoo* were the highly favored species in the study area due to their easiness of regeneration, better fuel wood quality and low smoke production. It was suggested that stress should be given for plantation of these species in agroforestry systems to achieve the need of the rural people for fuel wood and reduce the pressure from the prevailing state forests.

Reddy (2011) concluded that lack of appropriate technical knowhow and inadequate knowledge of the market of the products are the major constraints, agroforestry farmers are facing in India.

Mahapatra (2010) conducted study on planning economic land use models for dry land farm forestry in India and bring out that an economic estimation of dry land farming was undertaken to demonstrate the impact of trees on the yearly net profits of smallholding farms of eastern India.

Zeleke (2009) examined the traditional agroforestry practices in the Burkitu Peasant Association, Oromia, Ethiopia. The study revealed that farmers' preferences for specific niches of agroforestry were influenced by the types of components involved. Agroforestry practices that incorporated fruit-bearing crops and vegetables were highly preferred. It was also observed that larger farm sizes tended to encourage agroforestry practices, whereas farmers with small farms often viewed agroforestry as a potential loss of land that could otherwise be used for food and cash crop production.

Kareemulla *et al*. (2009) reported that the natural resources development in farmer's and common property resource lands through water conservation, plantations, micro and minor irrigation, renovation of water bodies, land development, irrigation facilities, flood and drought control and rural connectivity under the National Rural Employment Guarantee Scheme (NREGS) created ample employment and income opportunities for rural mass enhancing their livelihood assets (physical, natural, financial, human and social capital) and social security and reducing unemployment, migration and poverty in Ananthapur district of Andhra Pradesh

Dwivedi *et al*. (2009) conducted a study to examine the relationship between farmers' landholding size, age, and their preferences for multipurpose trees (MPTS) in agroforestry. The study found that the preferences for MPTS varied among different age groups. For respondents in the age group of 21-40 years (young), the preferred MPTS in descending order were Shisham, Teak, Neem, and Subabul. The preferences of respondents in the age group of 41-60 years (middle age) were more or less similar to the young respondents. However, for older respondents in the age group of 61-80 years, the preferred MPTS were Shisham, Teak, Siris, and Butea. The overall preference for MPTS, regardless of age, was found to be Shisham, Sagon, Neem, and Sirisis in descending order. Furthermore, the study revealed that the preferences for MPTS also varied based on the farmers' landholding size. Marginal farmers showed a preference for Shisham, Teak, Subabul, and Eucalyptus. Small farmers preferred Shisha, Neem, Eucalyptus, and Teak. On the other hand, larger farmers preferred Shisham, Teak, Eucalyptus, and Neem trees in descending order of preference. Overall, the reported preference for MPTS trees, in descending order, was found to be Shisham, Teak, Eucalyptus, and Neem.

Rahaman *et al.* (2008) reported from a case study to address the general constrain of lack of adoption in Litchi chinensis based agroforestry in North Bangladesh; that agroforestry and non-agroforestry farmers do not differ greatly in terms of educational level. They studied that lack of general education did not explain the low adoption rates of agroforestry.

Snelder and Lasco (2008) studied that smallholders of Asian countries including India have increasingly been involved in on-farm tree growing due to development of agroforestry systems. With the expansion of small-scale cultivation in numerous areas of the world, the awareness is increasing and land of smallholders are of increasing importance both in sustainable food production and protecting environmental services, such as biodiversity conservation, safeguarding of watershed and carbon sequestration.

Ali and Chaturvedi (2008) found that the major constraints faced by the farmers in adoption of different agroforestry systems were lack of group interest, shortage of labour, non-availability of healthy planting material, frequent occurrence of floods, lackof knowledge/skill, lack of technological knowledge, lack of family interaction and marketing facilities in India.

A study undertaken by Das *et al*. (2008) revealed that illiteracy, lack of practical knowledge, lack of exposure to training programme, problems of financial support, family discouragement and heavy burden due to dual responsibility are the important hindrances to the tribal livelihood and gender empowerment in rice based farming system as perceived by the people in India.

Sharma (2007) conducted a study on horticulture-based agroforestry systems in degraded lands in India. The research indicated that shrubs such as Jharber (*Ziziphus nummularia*) and caronda (*Carissa carandas*) were more suitable for farming in the natural or sown pastures of anjan grass (*Cenchrus ciliaris*) in the Bundelkhand region, where the soil is sandy loam, shallow, and underlain by a murram layer. Various aspects of the hortipastoral system were considered, including growth, tree spacing, nutritive value of tree leaf fodder, productivity, rooting system, and the effects of climate change. It was recommended that selecting appropriate species is crucial for establishing fruit-bearing trees in agroforestry systems, and the choice should be based on the fruit trees already being cultivated by farmers.

Mourlin (2007) reported that diversification of this household's livelihood activities through common property resource lands under National Rural Employment Guarantee Act (NREGA) created ample opportunities is forest based direct, secondary and self employment for the tribal communities enhancing their livelihood assets (physical, natural, financial, human and social capital) and social security and reducing unemployment, migration and poverty in Betul district of Madhya Prades, India.

Mishra *et al*. (2007) found that the management of forest resources through Joint Forest Management (JFM) accrued benefits to the rural poor in terms of fuel wood, fodder, timber and fruit availability, increased village forest area and natural beauty, soil and water conservation, environmental amelioration and climate control, flood and drought protection, agriculture and livestock support, employment and income generation and increasing living standards which profoundly improved the sustainable livelihood and development of forests.

An appraisal of livelihoods in rural India made by Singh (2005) identified several promotional factors that support forest based livelihood of the community. The most important of them are price of the forest produces availability of the valuable trees which provide fuel wood, fodder, timber, fruits and also fulfill consumption need, accessibility of the market, govt. support and role of traders.

Sood *et al.* (2005) evaluated tree species preferences of the farmers in Manipur so that in future optimum choice of trees can be made for effective application of agroforestry programmes in the State. Parkia roxburghii and Pinus spp. were found to be the most grown tree species in the valleys and hills respectively.

Elasha *et al*. (2005) reported that the access of forest resources drastically increased the poor people's natural/ biological capital (i.e., land, water, common-property resources, flora, fauna), social capital (i.e., community, family, social networks), human capital (i.e., knowledge, creation by skills), physicalcapital (i.e., roads, markets, clinics, schools, bridges) and financial capital (cash assets, remittances, savings, livestock, income levels, variability over time, access to credit, debt levels, etc.).

A study made by Pandey (2005) on the impact of Joint Forest Management (JFM) on rural livelihood assets status in the sample villages of Udaipur in Rajasthan found that the condition of capitals in the sample villages before and after implementation of JFM improved drastically. The increase in the daily wages given by the forest department to the village workers, development of entrepreneurial skills among villagers, increased availability of grasses, additional work during scarcity months and reducing the distress migration are the reasons for the progress in financial capital after JFM implementation.

An appraisal of livelihoods in India made by Singh (2005) showed that there are many ways in which forests contribute to the economy of poor households. Collection and sale of forest produces provide significant livelihood opportunities to the rural poor; require very little capital or any special skills like literacy; sales are possible in retail as well as in bulk; stored forests produces provide insurance against difficult periods to poor families; besides coming in handy for a number of other reasons, e.g. consumption as fruits, flowers, leaves, timber, oil for treatment, manure, fuel etc. Natural forests not only act as a savings account for people living in and aroundthem, but they also provide a range of products for subsistence.

The efficient land resource utilization through agroforestry plantation has the intrinsicability to provide multiple outputs and services, implies soil and water conservation, improves environmental condition, meets raw material needs of industries, generate cash returns, builds up livelihood assets (physical, natural, financial, human and social capital), improve the standard of living of rural poor and accomplish social security notably (Mohankumar and Miah, 2004; Gangadharappa *et al*., 2005).

Salam *et al*. (2000) and Dwivedi *et al.* (2009) both highlighted the positive correlation between landholding size and tree cultivation at the farm level. Their studies, conducted in Bangladesh and India respectively, indicated that larger landholdings have a greater tendency for tree growing. The researchers argued that as land becomes scarce, the primary focus on food production takes precedence over the long-term benefits provided by trees. Consequently, with decreasing landholding size, the likelihood of cultivating trees decreases as well, as farmers prioritize immediate food production needs.

Vishwanathan *et al*. (1998) studied that in a Silvipastoral study, the performance of different tree (*Albizia lebbeck*, *Grewia optiva*, *Bauhinia purpurea* and *Leucaena leucocephala*) and grass species *Chrysopogon fulvus* and *Eulaliopsis binataon* changes in soil fertility over the 14 year period of experimentation from 1980 to 1993 revealed that soil pH decreased markedly from 7.3 in 1979 to 6.3 in 1993.

Ray *et al*. (1996) found that meeting fuel, fodder and wood needs of the people is the most important motivational factor as perceived by the farmers for expansion of farm forestry programme followed by high lump sum return, utilization of unproductive land, availability of free seedlings and other inputs, little investments, availability of subsidy and utilization of free time in West Bengal, India.

Agroforestry is also providing livelihood opportunities through lac, apiculture and sericulture cultivation and suitable trees for gum and resin have been identified for development under agroforestry (Dhyani *et al*., 1989). In the present scenario of climate change, agro-forestry practices, emerging as a viable option for combating negative impacts of climate change. Therefore, it is one of the viable options to meet the ever growing need of burgeoning population.

Huxley (1985) studied that in agroforestry, tree and agricultural crops are combined together and they compete with each other for growth resources such as light, water and nutrients. Tree –crop interaction is simply how the components interact and affect each other in a given environment. More specifically, the biological potentials and restraints of agroforestry systems and environmental responses of plants components within them, is tree –crop interface. Tree–crop interaction is an important aspect in agroforestry. The positive (complementary) and negative (competitive) effects of tree in agroforestry systems have been realized by field observations.

2.3 Agroforestry systems and practices

Agroforestry system has been practiced for a long time throughout the world. With the establishment of WAFC (World Agroforestry Centre) the ancient practice of agroforestry was institutionalized. The WAFC with the help of global inventory contributes immensely in colleting, evaluating and disseminating information on new approaches of agroforestry system. According to Rafiq *et al*. (2000)

traditional agroforestry is the result of farmers' innovation and experimentation over centuries. Traditional agroforestry has been practiced for millennia by agrarian-based societies throughout the world (Garrity, 2006).

Agroforestry systems range from subsistence livestock silvo-pastoral systems to home gardens, on-farm timber production, tree crops of all types integrated with other crops and biomass plantations within a wide diversity of biophysical conditions and socio-ecological characteristics. The term has come to include the role of trees in landscape level interactions, such as nutrient flows from forest to farm, or community reliance on fuel, timber, or biomass available within the agricultural landscape (Zomer *et al.*, 2009). After a meta analysis covering more than 500 publications on agroforestry from 1992-2002, Montambault and Alvalpati (2005) reported that regarding system the focus has shifted from forest-like to silvopastoral systems.

Man has been practicing agroforestry since he learnt the art of cultivating agriculture crop and domestication of livestock and has never stopped using trees (Tewari, 1995). Agroforestry has been practiced for millennia by agrarian-based societies throughout the world (Garrity, 2006). The World Bank estimates that 1.2 billion people practice some form of agroforestry on their farms and in their communities (World Bank, 2004).

Ideally, agroforestry integrates a wide range of traditional practices that have been validated and adapted to local conditions over generations. Sustainable management and protection of the natural resource base by native and peasant communities is often an integral part of their livelihood strategy (Prins, 2000).

The promising tradition of tree inclusion in to the farmlands through retention of remnant or naturally regenerated indigenous tree species and undertaking plantation activities have been reported in Ethiopia. From a study on status of traditional agroforestry in Burkitu Peasant Association, Oromia, in Ethiopia, Zeleke, (2009) reported promising tradition of keeping trees on farmers' land. Homestead, farm boundary, trees on farm land, grazing land and live fence were the common niches where tree retention has been practiced. Among the aforementioned niches, homestead was the most preferred niche by the majority of the respondents followed by farm boundary and farm land. Similarly, home stead was the most preferred niche for tree plantation.

Kindu (2001) noted the types of traditional agroforestry practices in Yeku watershed northeastern Ethiopia as trees and shrubs in silvipastoral lands, trees on farmlands, trees along rivers, and trees in homesteads. Growing *Acacia albida* as a permanent tree crop, on farmlands with cereals, vegetables and coffee underneath or in between, is an indigenous agroforestry system in the Harrarghe highlands of Eastern Ethiopia (Poschen, 1986).

Agroforestry has a long tradition in the Indian subcontinent (India, Pakistan, Bangladesh, Nepal, Bhutan and Sri Lanka). Farmers in the subcontinent basically practice a mixed-farming system. The socio-religious fabric of the people of the subcontinent is interwoven to a very great extent with raising, caring for and respecting trees. Trees are integrated extensively in the crop- and livestock-production systems of the region according to the agroclimatic and other local conditions. Deliberate growing of trees in homesteads, on field bunds, their sporadic distribution in agricultural fields, and the systematic retention of shade trees in tea and coffee plantations are other common examples of prevalent agroforestry practices. Similarly, it is a common practice to utilize the open interspaces in the newly planted orchards and forests for cultivating crops for 2-3 years and to interplant shade tolerant crops such as turmeric and ginger later (Singh, 1987).

In Bangladesh there is a long tradition of tree growing in homesteads and homegardens like elsewhere in Southeast Asia (e.g., Ahmed and Ali, 2003). Likewise tree growing in the form of traditional forestry has been practiced in the form of village forests, tea and rubber gardens and shifting cultivation systems in hill forest (Islam, 2013). Whereas in present times homegardens cover only about 2.3 percent of the land (Jensen, 1995), village forests play a more important role supplying 80 to 82 percent of the forest products in villages (Forestry Master Plan, 1992). It is estimated that these forests cover about 270,000 ha (Forestry Master Plan, 1992) containing, amongst others, bamboo, palms, and trees (for fruit, fuelwood, construction, shade, and other multiple purposes).

In mid-hills of Nepal, shifting cultivation is practiced by ethnic people for generations (Regmi *et al*., 2005). Locally this form of farming is called Khoriya farming (Aryal and Kerkhoff, 2008; Dhakal, 2000). Under Khoriya farming generally steep to gentle steep land is cultivated using slash -and-burn techniques (Brady, 1996). Patches of forest land are first cleared off and subsequent burning of dried vegetation is done before sowing maize or leguminous crops. After one or two cycles of crops the land is abandoned for few years. In the mean time, farmers go for other patches of land to clear the vegetation for cultivation purpose. According to Aryal *et al*. (2009), Kerkhoff and Sharma (2006), and Regmi *et al*. (2005), Khoriya farmers are mostly food unsecure, marginalized and often they have to rely on wild and uncultivated plants for subsistence.

Nair (1993) stated that the word “systems” and “practices” are often used synonymously in agroforestry literature. However, some distinction can be made between these two concepts. An agroforestry system consists of one or more agroforestry practices that are practiced extensively in a given locality or area; the system is usually described according to its biological composition and arrangement, level of technical management or socio- economic features. From the early taungya systems to scattered trees on farm lands, agrisilviculture, silvipasture, agrihorticulture, hortipasture, energy farms, farm boundary planting, aquaforestry, home garden, slash and burn agriculture etc. are various forms of Agroforestry systems practiced throughout India (Nair, 1993).

2.4 Importance of agroforestry for livelihood

Beyene *et al*. (2018) observed that the agroforestry or homegarden agroforestry system had complex structure both vertically and horizontally, which in turn provide economic benefit and ecological service to the households. Land around the farmers house with trees are one of agroforestry practices known to be ecologically sustainable and diversifies livelihood of local community.

Haque (2014) had undertaken a study to determine the level of acceptability of agroforestry practices by the farmers of the Northern parts of Bangladesh especially Aditmari upazilla of Lalmonirhat district and its socio- economic impacts on local people livelihood. He stated that about 66.3% farmers had more income and the joint farm families were highest among all of them with a income of 66.1% and 71% of medium sized farms are working towards homestead agroforestry practices.

Johnson-Welch *et al.* (2000) reported that it is evident from the literature that agroforestry especially homestead agroforestry is a part of the agriculture and food production systems in many developing countries and are widely used as a remedy to alleviate hunger and malnutrition in the face of a global food crisis.

Chambers and Conway (1991) stated that a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

Jacob *et al*. (1987) reported that the economy of Sri Lanka is founded on agriculture and more than 35% of the 20 million people of SriLanka are engaged directly or indirectly in the agrarian sectors. Among the rural and urban households in SriLanka for centuries has been a long-standing practice of agroforestry.

2.5 Function of trees in climate change

According to Mattssona *et al*. (2014), homegarden agroforestry systems offer significant potential for mitigating and adapting to climate change. These systems play a multifunctional role by generating income, providing food, and offering various ecosystem services. By reducing reliance on natural forests, homegardens help alleviate pressure on these ecosystems while also storing carbon, thereby contributing to climate change mitigation. The study's findings reveal substantial variations in carbon stock and tree diversity within homegardens, providing valuable insights into their expansion potential and their capacity to enhance climate change mitigation and adaptation efforts.

IPCC (2013) confirmed that global warming of our climate system is unequivocal and is associated with the observed increase in anthropogenic greenhouse gas concentrations and it is necessary to keep the temperature rise less than 2°C relative to preindustrial levels and that CO_2 emissions should be reduced globally by 41–72% by 2050 and by 78–118% by 2100 with respect to 2010 levels.

Sampson *et al.* (1992) investigated that forest are the most critical for taking C out of circulation for long periods of time. Of the total amount of C tied up in earthbound forms, an estimated 90% is contained in the world’s forests, including trees and forest soils. For each cubic foot of merchantable wood produced in a tree, about 33 pound (lb) (14.9 kg) of C is stored in total tree biomass.

2.6 Tree species diversity in agroforestry system

Beyene *et al*. (2018) reviewed that the homestead agroforestry system is more complex in terms of multi-strata than other agroforestry systems. Among 138 households, 80% were practicing the homestead agroforestry system. The study recorded a total of 22 plant species from 15 families in the sampled home gardens, with 3-5 different species of plants per quadrant. The Shannon diversity index ranged from 2.21 to 2.44. The complex structure of the homestead agroforestry system provides economic benefits and ecological services to the households.

Mattsson *et al*. (2015) carried out a study in Sri Lanka and revealed that the homesteads featured 70 different tree and plant species belonging to 55 genera and 30 families, with a total of 4,278 trees measured. The most frequently occurring species was the Bead Tree (*Azadirechta indica* A. Juss., n = 1014), comprising 24% of all trees measured, followed by Cashenut (*Anacardium occidentale* L., n = 509, 12%) and Coconut (*Cocos nucifera* L., n = 362, 8%). The highest mean diversity of trees was found in small-sized homesteads, followed by medium and large homesteads.

Mannan *et al*. (2013) reported that plant biodiversity in the haor homesteads of Bangladesh contains 84 useful plant species, with 33.33% fruits, 28.57% timber, 22.62% summer vegetables and 15.48% winter vegetables. Coconut, Mahagani, brinjal, and bottle gourd were found to be most prevalent in their respective categories. The inter-species diversity was highest (0.799) in the fruit species and lowest in summer vegetable.

Hayat and Kudus (2010) found from a study that a total of 3414 individual trees representing 120 species, 81 genera, and 31 families in a logged-over coastal forest in Malaysia. Species diversity was high with Simpson's index of diversity with a value of 0.96, while Shannon-Weiner index was 5.42.

Henry *et al*. (2009) reported a total of 49 tree species in the two locations of Western Kenya. Values of the Shannon index (H), used to evaluate biodiversity, ranged from 0.01-0.03 in woodlots, from 0.4–0.6 in food crop plots, and from 1.3–1.6 in homesteads. *Eucalyptus saligna* was the most frequent tree species found as individual trees (20%).

CHAPTER III

MATERIALS AND METHODS

The methodology used in conducting any research is critically important and deserves careful consideration. It enables the researcher to collect valid and reliable information in terms of hypothesis or research instrument and to analyze the information properly to arrive at valid results.

3.1 Geographical location of the study area

The study was conducted in two villages namely Uttar Digholdi and Illisha of Uttar Digholdi and Illisha union, respectively under Bhola sadar upazila and in two villages namely Uttar Joynagar and Charpata under Uttar Joynagar and Charpata union, respectively under Daulat Khan sadar upazila in Bhola district. The study area is located in the south part of Bangladesh. Bhola is a district in Barisal Division, Bangladesh. The district consists of 7 upazilas; among them Bhola sadar and Daulat Khan upazilas were the study area. The locations of the study area was showed in the Figure 3.1.

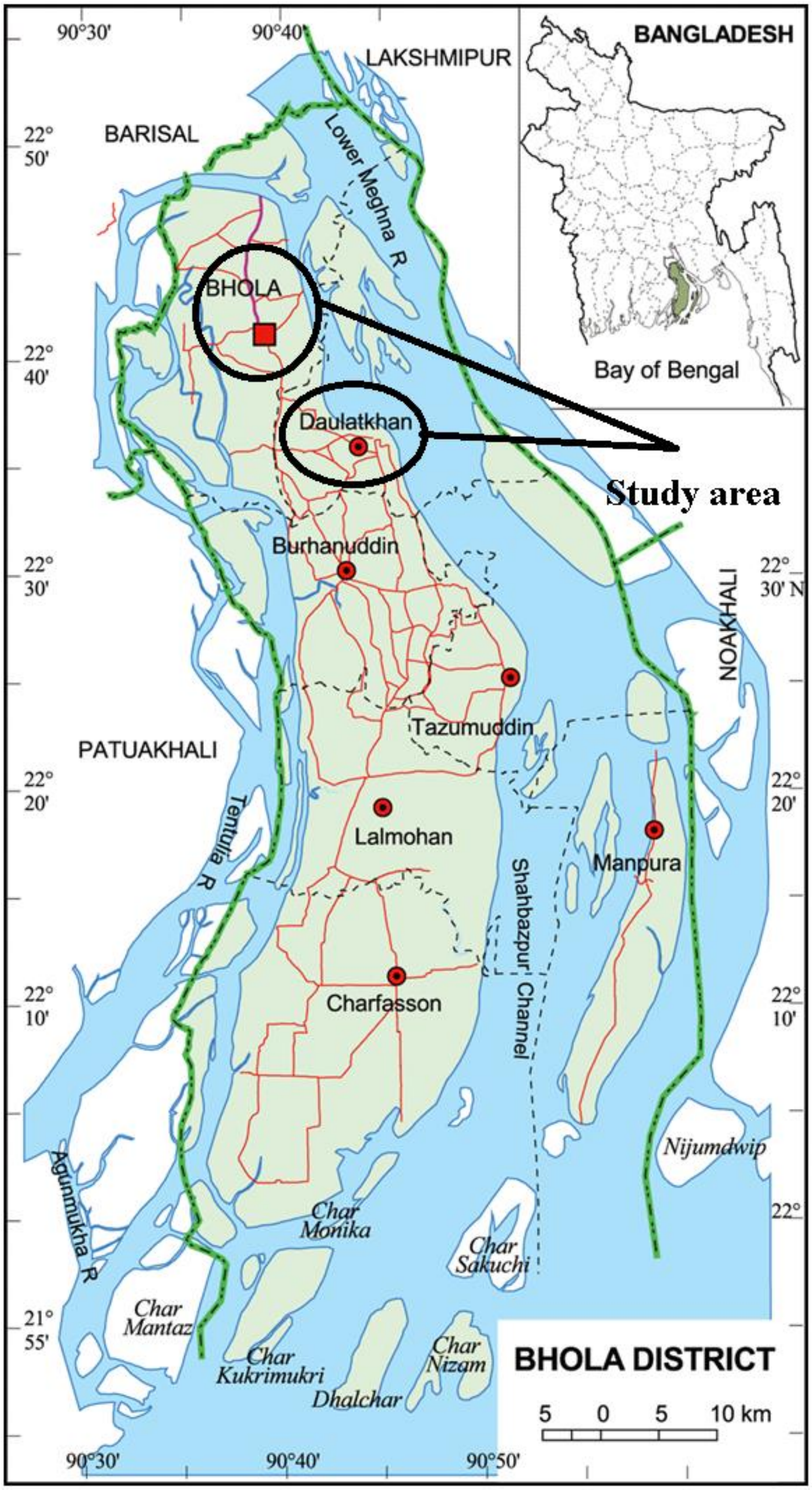

Figure 3.1 Location of the study area

3.2 Site selection and sampling procedure

This study was conducted in Bhola district that was purposively selected. Bhola district is consisting of 7 upazilas. Out of 7 upazilas, Bhola sadar and Daulat Khan upazila were selected randomly. Two villages from each upazila named Uttar Digholdi and Illisha from Bhola sadar upazila and Uttar Joynagar and Charpata from Daulat Khan upazila were randomly selected. There are total 1003 of different farm families in these selected villages. Out of 1003 farm families, a sample of 15%, i.e., 150 household were selected by stratified random sampling method (Table 3.1). Then finally 64 representative farm families were selected for questionnaire survey and tree diversity assessment was done from each homestead. Final selection of homestead has been done by using (Yamane, 1967) formula:

$$n= N/\{1+N (e^2)\}$$

Where, n = Sampling size

N = Population

e = Error of precision

Table 3.1 Distribution of population and sample size in four selected villages under two unions Bhola sadar and Daulat Khan upazila in Bhola district

Upazila	Village	No. of total households	No. of households primary selected	No. of households finally selected for data collection
Bhola Sadar	Uttar Digholdi	253	38	17
	Illisha	307	45	20
Daulatkhan	Uttar Joynagar	243	37	15
	Charpata	200	30	12
Total		1003	150	64

3.3 Household characteristics data

In 64 households, initially a questionnaire survey was conducted. Field data collection was made by physical measurement directly from the study sites. Demographic data of household (age, education, family size) were recorded with the help of family members. Socioeconomic household data such as homestead size (dwelling + homegarden), and agricultural land holding, annual income from homestead, income from other sources including agricultural land were also recorded. Homestead and agricultural land holdings size were recorded in decimal which further subsequently converted into hectare. For comparison the homesteads were categorized into four size group namely marginal or landless (<0.08 ha), small (0.09-0.14 ha), medium (0.15-0.20 ha) and large (> 0.2 ha).

3.4 Variables of the study and development of the research instruments

In social research, the selection and measurement of variables constitute a significant task. The independent variables were: age, education levels, family size, farm size, homestead size, total annual income, annual income from homestead and changes of livelihood status of the farmers. The farmer's opinion regarding the impact of homestead agroforestry on livelihood status was the dependent variable. Ultimately eight independent and one dependent variable were selected for this study. These variables are described below:

3.4.1 Measurement of independent variables

The following independent variables were included in the study:

i) Age
ii) Education
iii) Family size
iv) Farm size
v) Homestead size

vi) Crop land size

vii) Annual income and

viii) Changes of livelihood status of the farmers

3.4.1.1 Age

The age was defined as the period of time from the birth of a respondent to the time of interview. It was operationally measured in terms of actual age in years.

3.4.1.2 Level of education

Education of a respondent was measured in terms of classes passed by him. For example, if a respondent passed the final examination of class V in the school, a score of 5 was taken for calculating his education score. If a respondent had education outside the school and if the levels of education was seemed to equivalent to that of class V of the school, then his education score was taken as 5. A respondent who did not know reading or writing had education score of zero (0).

3.4.1.3 Family size

Family member of a respondent was determined in terms of the total number of members of each respondent. The family member included respondent himself, spouse, sons, daughters and other dependents.

3.4.1.4 Farm size

Land is the most important capital to a farmers and size influences on personal characteristic of farmer. Farm size was expressed as hectare and was computed by using the following formula:

Farm size = Homestead area + Own land under cultivation + Cultivated area taken under lease + ½ (Cultivated area given to others as borga + cultivated area taken from others as borga).

3.4.1.5 Homestead size

It was measured by the area of the raised land in which the household has its entire living room, livestock and poultry shed, yard under vegetable, home garden, fruit and timber trees, backyard, bushes, bamboo bunches, pond etc. It expressed in hectare.

3.4.1.6 Crop land size

Crop land size was measured by the land that was used for crop production and crop management through all the year round. It also includes the aspects that are used to produce human benefits by their intensive utilization. It was express in hectare.

3.4.1.7 Total annual income

Total annual income was measured by the sum of all income sources of a farmer in a year (agricultural income like framing, cropping etc. and non-agricultural income like business, service, saving, labour, other etc.). A score of 1 (one) was given for each thousand Taka.

3.4.1.8 Livelihood status

This section presents the livelihood status possessed by farmers in the study area. The assessment of the perception of farmer on ten livelihood indicators, were used to determine the existing livelihood status. The data obtained from 64 farmers by administering a simple scale 0 to 3 for the score of ten livelihood indicators, whereby 0 stands for 'no livelihood status', 1 for 'lower status', 2 for 'dedium status' and 3 for 'high status'. A rank order of ten indicators was listed based on the total scores according to ascending order from least important to most important, whereby rank 1 denotes 'least important' and rank 10 denotes 'most important' (Table 3.2).

Table 3.2 Impact of homestead or crop land or road side agroforestry on livelihood status of the farmers and scoring was given by livelihood indicators

Qualitative rank	Livelihood indicators	Evaluation scale	Score (0-3)
1.	Water facilities	0 - 3	
2.	Sanitation	0 - 3	
3.	Educational status	0 - 3	
4.	Freedom in cash expenditure	0 - 3	
5.	Participation in social activities	0 - 3	
6.	Clothing status	0 - 3	
7.	Self transportation	0 - 3	
8.	Food availability	0 - 3	
9.	Health situation	0 - 3	
10.	Housing condition	0 - 3	
Total			

Based on the obtained scores, farmer are classified into three categories such as ‘low livelihood status’ (0 - 10), ‘medium livelihood status’ (11 - 20) and ‘high livelihood status’ (21 - 30).

3.4.1.9 Changes of livelihood status of the farmers

This section presents the changes of livelihood status possessed by farmers in the study area due to homestead or crop land or road side agroforestry. The assessment of the perception of farmer on six livelihood indicators, were used to determine the changing of livelihood status. The data obtained from 64 farmers by administering a simple scale 0 - 3 for the score of six livelihood indicators, whereby 0 stands for ‘no changes of livelihood status’, 1 for ‘low changes’, 2 for ‘medium changes’ and 3 for ‘high changes’. Six indicators were listed based on the total scores of changing livelihood of the farmers using homestead agroforestry (Table 3.3).

Table 3.3 Changing of livelihood of status of farmers through homestead or crop land or road side agroforestry regarding livelihood indicators

Sl. No.	**Livelihood indicators**	**Changes of livelihood status compared to previous situation (changing scoring; 0-3)**				**Total**
		No (0)	Low (1)	Medium (2)	High (3)	
1.	Changes in food habit					
2.	Changes in clothing					
3.	Changes in residence					
4.	Changes in education					
5.	Changes in health issue					
6.	Changes in sanitation					
	Total					

Based on the obtained score farmer are classified into three categories such as 'low changes of livelihood' (0-6), 'medium changes of livelihood' (7-12) and 'high changes of livelihood' (13-18).

3.4.2 Measurement of dependent variable: Tree species diversity

Tree species diversity of homestead or crop land or road side agroforestry was the dependent variable of the study. Tree species diversity was estimated from the Shannon Wiener diversity Index.

Tree species diversity, $Pi = S/n$

Where, S = Total number of sample species (types of trees),

n = Total number of trees (plant species) found in a sample community.

3.5 Tree species identification

Tree species were identified with their botanical names in the field and cross-checked by using different identification literature. The mentioned literature was also used to determine scientific names for a few species not identified in the field, but only recorded with their local names. Tree species diversity was assessed within the fixed boundaries of the sample homegardens acquiring common names that subsequently translated into botanical names. An index was setup based on the number of species and their frequency in homegardens. For this study, mainly Shannon-Wiener diversity index (H) was used due to its suitability for evaluating diversity of tree species. The Shannon–Wiener diversity characterizes the proportion of species abundance in the population being at maximum when all species are equally abundant and the lowest when the sample contained one species. The proportion of species (i) relative to total number of species (Pi) was calculated and then multiplied by the natural logarithm of the same proportion (ln Pi). The resulting product is summed across species, and multiplied by -1.

1. Shannon-Wiener diversity index, H = -∑ Pi InPi

Where, Σ= Summation

H = Shannon index

Pi = Proportion of total sample represented by species 'i'. Total no. of individual species 'i', divided by total no. of plant species 'n' found in a sample community.

n = No. of species

2. Diversity index, D = S/N

Where, D = Diversity Index,

S = Total number of species,

N = Total number of individuals

3. Index of Dominance, ID= Σ $(Pi * Pi)$

Where, ID = Index of Dominance

Pi = Proportion of total sample represented by species i. Total no. of individual species i, divided by total no. of plant species found in a sample community.

4. Species richness index, R = (S-1)/ log N

Where, R = Species richness index,

S = Total no. of species,

N = Total no. of individuals of all the species

5. Species evenness index, E = H / log S

Where, E = Species evenness index,

H = Shannon-Winner index of diversity

S = Total no. of species

3.6 Collection of data

Data for the study were collected through personal interview by the researcher himself during October 2021 to January 2022 using the interview schedule. To get actual and valid information from them, all possible efforts were made to explain the purpose of the study to respondents in order. The interview was conducted with the respondents in their house. Proper rapport was establishment so that they did not feel hesitation to furnish proper response to the questions and statements in the schedule. The questions were explained and clarified whenever any respondent felt difficulty in answering the question. Ten farmers were kept in the reserve list during final collection.

3.7 Compilation of data

After completion of field survey all the data of the interview schedule were compiled. Local units were converted into standard unit. Appropriate coding and scoring technique was followed to convert the qualitative data into quantitative forms. The responses of the individual garden owner contained in the interview schedules were transferred to a master sheet for entering the data in the computer. As soon as the data entered into the computer, it was then analyzed in accordance with the objectives of the study.

3.8 Hypothesis

A null hypothesis states that there is no relationship between the concerned variable. If a null hypothesis is rejected on the basis of statistical test, it is concluded that there is a relationship between the concerned variables. However, following null hypotheses was formulated for the present study:

- There was no relationship between the selected characteristics of the respondents and their tree species diversity in homestead agroforestry.
- There was no relationship between the selected characteristics of the respondents and their tree species diversity in crop land agroforestry.
- There was no relationship between the selected characteristics of the respondents and their tree species diversity in road side agroforestry.

The selected characteristics were ‘age, education, family size, farm size, homestead size, crop land size, total annual income, livelihood status and changing of livelihood status’ of the farmers and the dependent variable was ‘tree species diversity in homestead, cropland and road side agroforestry’.

3.9 Analysis of data

After compilation of data, data were coded, categorized and fed in computer and analyzed using computer software packages MS Excel 2010 and SPSS 21 versions. Local units were converted into standards units. The statistical measures such as number, percentage, range, mean and standard deviation were used in describing the variables of the study. For clarity of understanding Tables and Figures were also used for presentation the data. From the primary data, indices of diversification of plant species (species diversity index, species richness index) were calculated following Shannon and Weaver (1949). Pearson’s Product Moment Correction Coefficient (r) was used to find out the relationship between impact of homestead agroforestry on livelihood status of the farmers and their selected characteristics (age, education, family size, farm size, homestead size, total annual income, annual income from homestead and changing of livelihood status of the farmers). At least 0.05 level of probability with an accompanying 95 percent confidence level was used as the basis for rejection of a null hypothesis throughout the study.

CHAPTER IV

RESULTS AND DISCUSSION

The present work entitled "impact of homestead agroforestry systems on tree species diversity and farmers livelihood of Bhola sadar and Daulat Khan upazila in Bhola district" was carried out during October 2021 to January, 2022. The results obtained from the investigations undertaken, probable reasons for getting such results together with corresponding Tables and Figures are presented in this chapter.

4.1 Demographic and socio-economic characteristics of the respondents of the study area

Nine characteristics of independent variables of the study have investigated and the descriptions of each of the individual characteristics are presented in Table 4.1

Table 4.1 Description of farmers characteristics treated as independent variables of the study (N= 64).

Characteristics	Measuring unit	Observed range	Mean	Standard deviation
Age	Years	24-65	42.67	12.75
Education	Level of class	0-16	8.33	3.40
Family size	Numbers	2-9	4.70	2.02
Farm size	Hectare	0.10-3.20	1.56	0.788
Homestead size	Hectare	0.01-0.52	0.199	0.114
Crop land size	Hectare	0.09-2.76	1.362	0.687
Total annual income	Thousand	18.00-306	93.22	73.25
Livelihood status	Scale scores	8-26	16.98	4.51
Changing of livelihood status	Scale scores	4.00-16.00	9.89	3.31

4.1.1 Age

The age of the respondents ranged from 24 to 65 years with the average of 42.67 years and standard deviation of 12.75. The respondents were grouped into three categories- young (up to 30 years), middle (31 to 50 years) and old (above 50 years) on the basis of their age. Number and percent distribution of farmers according to their age group were given in Table 4.2. Results revealed that the majority of the respondent (46.88%) was in the middle aged category, 26.87% of the respondents were in both the young aged and old aged category in the study area.

Table 4.2 Distribution of respondents according to their age.

Category	Respondent (Number)	Percent	Average (Years)	Standard deviation
Young age (up to 30 years)	17	26.56	42.67	12.75
Middle age (35 to 50 years)	30	46.88		
Old age (above 50 years)	17	26.56		
Total	64	100.00		

4.1.2 Education

The education level of the respondents ranged from 0-16 with an average of 8.33 and standard deviation of 3.40 of schooling. In this study 60.94% of the farmers had secondary level education which was highest in the study area, whereas 25.00% farmers were in higher secondary level of education (Table 5). Similarly, illiterate respondents were minimum (6.25%) whereas 7.81% respondents were in primary level education (Table 4.3).

Table 4.3 Categorization of respondents according to their education

Category	Respondent (Number)	Percent	Average (Scale scores)	Standard deviation
Illiterate (0)	4	6.25	8.33	3.40
Primary level (class 1 to 5)	5	7.81		
Secondary level (class 6 to 10)	39	60.94		
Above secondary level (11 or above)	16	25.00		
Total	64	100.00		

4.1.3 Family size

Household members of study area were ranged from 2 to 9 with mean and standard deviation of 4.70 and 2.02, respectively (Table 4.1) and were categorized into three groups as small, medium and large (Table 4.4). Results indicated that the majority of the farmers (50.25%) belonged to small size family whereas 31.25% of the respondents had medium size family and 18.75% of them belonged to large family.

Table 4.4 Family sizes of sampled farmers

Category	Respondent (Number)	Percent	Average (No.)	Standard deviation
Small (1-4)	32	50.00	4.70	2.02
Medium (5-6)	20	31.25		
Large (above 7)	12	18.75		
Total	64	100.00		

4.1.4 Farm size

Respondents of the study area were categorized into four groups according to their farm size (Table 4.5). The farm size of the respondents varied from 0.10 to 3.20 hectare with the mean of 1.56 and standard deviation of 0.788. Data presented in Table 4.5 showed that the highest proportion (45.31%) of the respondents were medium category while 28.13%, 17.19% and 9.38% of the farmers were in large, small and marginal farm categories, respectively. The farmers having marginal farm size were the lowest percentage in the study area.

Table 4.5 Distribution of the farmers on the basis of their farm size

Category	Respondent (Number)	Percent	Average (ha)	Standard deviation
Marginal (up to 0.50 ha)	6	9.38	1.56	0.788
Small (0.51 to 1.00 ha)	11	17.19		
Medium (1.01 to 2.00 ha)	29	45.31		
Large (above 2.00 ha)	18	28.13		
Total	64	100.00		

4.1.5 Homestead size

The homestead size of the farmer ranged from 0.01 - 0.52 hectare with an average of 0.199 hectare and standard deviation of 0.114 (Table 4.1). Among the respondents, the highest portion (35.94%) was in medium category; followed by 29.69% respondents were in large category. The minimum respondents, 12.50% were landless and 21.88% were considered as small farmer according to homestead size (Table 4.6).

Table 4.6 Categorization of respondents according to their homestead size

Category	Respondent (Number)	Percent	Average (ha)	Standard deviation
Landless/marginal (up to 0.08 ha)	8	12.50	0.199	0.114
Small (0.09 to 0.14 ha)	14	21.88		
Medium (0.15 to 0.20 ha)	23	35.94		
Large (above 0.21 ha)	19	29.69		
Total	64	100.00		

4.1.6 Crop land size

Respondents of the study area were categorized into four groups by their crop land size (Table 4.7). The crop land size of the respondents of the study area varied from 0.09 to 2.76 hectare with the mean value of 1.362 and standard deviation of 0.687. Data presented in Table 4.7 showed that the highest portion (46.88%) of the respondents were medium while 23.44%, 20.30% and 9.38% were in small, large and marginal crop land size categories, respectively. The marginal farmer was the lowest in number by crop land size under the study area.

Table 4.7. Categorization of respondents according to their crop land size

Category	Respondent (Number)	Percent	Average (ha)	Standard deviation
Marginal (up to 0.50 ha)	6	9.38	1.36	0.687
Small (0.51 to 1.00 ha)	15	23.44		
Medium (1.00 to 2.00 ha)	30	46.88		
Large (above 2.00 ha)	13	20.30		
Total	64	100.00		

4.1.7 Total annual income

Total annual income of the farm families ranged from Tk. 18 thousand to Tk. 306 thousand with an average 93.22 thousand having standard deviation of 73.25. The respondents are classified three categories based on their total annual income; low income (up to Tk. 60 thousand) category, medium income (Tk. 60-120 thousand) and high income (above Tk. 120 thousands) categories. Data presented in Table 4.8 indicated that majority (43.75%) of the respondents had low income category whereas 34.38% of the respondents had medium income category and the minimum 21.88% of the respondents in high income category.

Table 4.8 Distribution of respondents according to their total annual income

Category	Respondent (Number)	Percent	Average ('000' Tk.)	Standard deviation
Low income (up to 60000 Tk.)	28	43.75	93.22	73.25
Medium income (60001-120000 Tk.)	22	34.38		
High income (above 120000 Tk.)	14	21.88		
Total	64	100.00		

4.1.8 Livelihood status of farmer

This section presents the livelihood status possessed by farmers in the study area. The livelihood status of farmer obtained by calculation of ten livelihood indicators. Here, farmers are classified into three categories. Table 4.9 showed that the majority of the farmers were distributed under medium livelihood status (67.19%), while 23.44% belonged to high livelihood status while only 9.38% farmers were under low livelihood status.

Table 4.9 Distribution of respondents based on the impact of homestead agroforestry on livelihood status of farmers

Category	Respondent (Number)	Percent	Average (Scale scores)	Standard deviation
Low livelihood status (0-10)	6	9.38	16.98	4.51
Medium livelihood status (11-20)	43	67.19		
High livelihood status (21-30)	15	23.44		
Total	64	100.00		

4.1.9 Changing of livelihood status of farmer through agroforestry

The changes of livelihood status of farmers due to homestead agroforestry practices, changing livelihood status of farmer obtained by calculation of six livelihood indicators. Here, farmers are classified into three categories. Table 4.10 showed that the majority of the farmers were in medium changes of livelihood status (50.00%), while 32.81% belonged to high changing of livelihood status whereas only 17.19% of the respondents were under low changing of livelihood status due to homestead agroforestry practices. Haque (2014) found similar result with the present study and reported that about 66.3% farmers had more income and the joint farm families were highest among all of them with a income of 66.1% and 71% of medium sized farms are working towards homestead agroforestry practices.

Table 4.10 Distribution of respondents based on their changes of livelihood status due to homestead agroforestry

Category	Respondent (Number)	Percent	Average (Scale scores)	Standard deviation
Low changes of livelihood (0-6)	11	17.19	6.58	4.46
Medium changes of livelihood (7-12)	32	50.00		
High changes of livelihood (13-18)	21	32.81		
Total	64	100.00		

4.2 Tree species diversity

Selected study area composed with multiple tree species in homestead, crop land and road side. Abundance of tree species in total at homestead, crop land and road side and their uses are presented in Table 4.11, 4.12 and 4.13. A total of 33 plant species of 19 families in homestead, 18 plant species of 12 families in crop land and 13 plant species of 7 families in road side were recorded from the set of 64 household surveys. Tree species in the homesteads, crop land and road side are used mainly for fruit, fuel, and timber purposes. Non wood products and services such as vegetables, oil, medicines, resins etc. are provided by different tree species.

In homestead agroforestry, among 33 plant species major seven species were found in dominant category than others and the highest percent occurrence was found for *Mangifera indica* (11.48%) followed by *Cocos nucifera* (9.50%), *Musa spp.* (9.47%), *Albizia saman* (9.10%), *Artocarpus heterophyllus* (8.51%), *Areca catechu* (6.33%) and *Swietenia macrophylla* (4.78%) (Table 4.11).

In crop land agroforestry, among 18 plant species, major four species were found in dominant category than others and the highest percent occurrence was found for *Areca catechu* (15.20%) followed by *Artocarpus heterophyllus* (11.92%), *Mangifera indica* (10.73%) and *Musa spp.* (9.54%) (Table 4.12).

In road side agroforestry, among 13 plant species, major four species were found in dominant category than others and the highest percent occurrence was found for *Albizzia procera* (17.54%) followed by *Albizia saman* (13.99%), *Mangifera indica* (12.73%) and *Artocarpus heterophyllus* (10.86%) (Table 4.13).

Mattsson *et al*. (2015) found 70 different tree and plant species belonging to 55 genera and 30 families, with a total of 4,278 trees measured in Sri Lanka. They found the most frequently occurring species was the Bead Tree (*Azadirechta indica* A. Juss., n = 1014), comprising 24% of all trees measured, followed by Cashenut (*Anacardium occidentale* L., n = 509, 12%) and Coconut (*Cocos nucifera* L., n = 362, 8%). Mannan *et al*. (2013) found in the haor homesteads of Bangladesh contains 84 useful plant species, with 33.33% fruits, 28.57% timber, 22.62% summer vegetables and 15.48% winter vegetables. Coconut, Mahagani, brinjal, and bottle gourd were found to be most prevalent in their respective categories.

Table 4.11 List of homestead tree species and uses at Bhola sadar and Daulatkhan upazila in Bhola district

Sl. No.	Common Name	Scientific name	Family	Abundance (Total no. of individuals)	Percentage of abundance	Plant type	Uses
1	Coconut/Narkel	*Cocos nucifera*	Arecaceae	288	9.50	Tr	1, 2, 7
2	Shil Koroi/Raintree	*Albizia saman*	Mimosaceae	276	9.10	Tr	2, 3
3	Jalpai	*Elaeocarpus tectorius*	Elaeocarpaceae	12	0.40	Tr	1, 2, 3
4	Chalta	*Dilenia indica*	Dilleniaceae	26	0.86	Tr	1, 3
5	Mango	*Mangifera indica*	Anacardiaceae	348	11.48	Tr	1, 2, 3, 5
6	Amra/Hog pulm	*Spondias spp.*	Anacardiaceae	30	0.99	ST	1, 5, 6
7	Koroi	*Albizzia procera*	Mimosaceae	108	3.56	Tr	2, 3
8	Betelnut	*Areca catechu*	Arecaceae	192	6.33	Tr	1, 2, 4, 7
9	Mahogany	*Swietenia macrophylla*	Meliaceae	145	4.78	Tr	2, 3
10	Tamarind/Tetul	*Tamariandus indica*	Caesalpiniaceae	22	0.73	Tr	1, 3
11	Khejur/Date Palm	*Phoenix sylvestris*	Arecaceae	105	3.46	Tr	1, 2, 3, 6
12	Tal/Palmyra Palm	*Borassus flabellifer*	Arecaceae	114	3.76	Tr	1, 2, 3, 7
13	Sissu	*Dalbergia sisso*	Fabaceae	21	0.69	Tr	2, 3, 6
14	Kathal/Jackfruit	*Artocarpus heterophyllus*	Moraceae	258	8.51	Tr	1, 2, 3, 5
15	Shimul/Cotton	*Bombax ceiba*	Malvaceae	12	0.40	Tr	2, 3, 6
16	Papaya	*Carica papaya*	Caricaceae	123	4.06	Sh	1
17	Neem	*Azadirachta indica*	Meliaceae	65	2.14	Tr	2, 3, 6
18	Jamrul	*Syzygium sumarengense*	Myrtaceae	23	0.76	Tr	1,3
19	Litchi	*Litchi chinensis*	Sapindaceae	72	2.37	Tr	1, 2, 3, 5
20	Teak/Segun	Tectona grandis	Verbenaceae	16	0.53	Tr	2, 3
21	Bel/Wood Apple	Aegle marmelos	Rutaceae	9	0.30	Tr	1, 3
22	Sajna	Moringa oleifera	Moringaceae	32	1.06	ST	1, 5, 6

23	Bamboo	Bambusa sp.	Gramineae	61	2.01	H	3, 4
24	Kul	Zizyphus mauritiana	Rhamnaceae	78	2.57	ST	1, 5
25	Kamranga	Averrhoa carambola	Oxalidaceae	9	0.30	Tr	1, 3
26	Lebu/Lemon	Citrus limon	Rutaceae	63	2.08	Sh	1, 6
27	Payera/Guava	Psidium guajava	Myrtaceae	82	2.70	ST	1, 2
28	Jam/Black Berry	Syzygium cumini	Myrtaceae	8	0.26	Tr	1, 2, 3
29	Akashmoni	Acacia auriculiformis	Fabaceae	27	0.89	Tr	2, 3
30	Kola/Banana	Musa spp.	Musaceae	287	9.47	Sh	1, 4, 5
31	Jambura/Pummelo	Citrus grandis	Rutaceae	54	1.78	Tr	1, 3
32	Ipil-ipil	Leucaena leucocephala	Fabaceae	52	1.72	Tr	3, 4, 5
33	Mingiri	Cassia siamea	Caesalpiniaceae	14	0.46	Tr	2, 5
Total				3032	100.00		

Plant type: Tr: tree, H: herb, Sh: shrub and ST = herb+shrub

Uses: 1: food/fruit, 2: timber, 3: fuel wood, 4: fence, 5: fodder, 6: medicine and 7: others

Table 4.12 List of tree species in crop land with uses observed in Bhola sadar and Daulatkhan upazila in Bhola district

Sl. No.	Common Name	Scientific name	Family	Abundance (Total no. of individuals)	Percentage of abundance	Plant type	Uses
1	Mango	*Mangifera indica*	Anacardiaceae	72	10.73	Tr	1, 2, 3, 5
2	Kathal/Jackfruit	*Artocarpus heterophyllus*	Moraceae	80	11.92	Tr	1, 2, 3, 5
3	Litchi	*Litchi chinensis*	Sapindaceae	21	3.13	Tr	1, 2, 3, 5
4	Coconut/Narkel	*Cocos nucifera*	Arecaceae	32	4.77	Tr	1, 2, 7
5	Betelnut	*Areca catechu*	Arecaceae	102	15.20	Tr	1, 2, 4, 7
6	Tal/Palmyra Palm	*Borassus flabellifer*	Arecaceae	42	6.26	Tr	1, 2, 3, 7

7	Khejur/Date Palm	*Phoenix sylvestris*	Arecaceae	48	7.15	Tr	1, 2, 3, 6
8	Neem	*Azadirachta indica*	Meliaceae	10	1.49	Tr	2, 3, 6
9	Mahogany	*Swietenia macrophylla*	Meliaceae	36	5.37	Tr	2, 3
10	Teak/Segun	*Tectona grandis*	Verbenaceae	13	1.94	Tr	2, 3
11	Sissu	*Dalbergia sisso*	Fabaceae	20	2.98	Tr	2, 3, 6
12	Shimul/Cotton	*Bombax ceiba*	Malvaceae	14	2.09	Tr	2, 3, 6
13	Lebu/Lemon	*Citrus limon*	Rutaceae	10	1.49	Sh	1, 6
14	Payera/Guava	*Psidium guajava*	Myrtaceae	22	3.28	ST	1, 2
15	Chalta	*Dilenia indica*	Dilleniaceae	16	2.38	Tr	1, 3
16	Papaya	*Carica papaya*	Caricaceae	48	7.15	Sh	1
17	Kola/Banana	*Musa spp.*	Musaceae	64	9.54	Sh	1, 4, 5
18	Akashmoni	*Acacia auriculiformis*	Fabaceae	21	3.13	Tr	2,3
Total				671	100.00		

Plant type: Tr: tree, H: herb, Sh: shrub and ST=herb+shrub

Uses: 1: food/fruit, 2: timber, 3: fuel wood, 4: fence, 5: fodder, 6: medicine and 7: others

Table 4.13 List of tree species in road side with uses observed in Bhola sadar and Daulatkhan upazila in Bhola district

Sl. No.	Common Name	Scientific name	Family	Abundance (Total no. of individuals)	Percentage of abundance	Plant type	Uses
1	Koroi	*Albizzia procera*	Mimosaceae	84	17.54	Tr	2, 3
2	Shil Koroi/Raintree	*Albizia saman*	Mimosaceae	67	13.99	Tr	2, 3
3	Mango	*Mangifera indica*	Anacardiaceae	61	12.73	Tr	1, 2, 3, 5
4	Kathal/Jackfruit	*Artocarpus heterophyllus*	Moraceae	52	10.86	Tr	1, 2, 3, 5
5	Tal/Palmyra Palm	*Borassus flabellifer*	Arecaceae	34	7.10	Tr	1, 2, 3, 7

6	Betelnut	*Areca catechu*	Arecaceae	42	8.77	Tr	1, 2, 4, 7
7	Coconut/Narkel	*Cocos nucifera*	Arecaceae	27	5.64	Tr	1, 2, 7
8	Khejur/Date Palm	*Phoenix sylvestris*	Arecaceae	24	5.01	Tr	1, 2, 3, 6
9	Mahogany	*Swietenia macrophylla*	Meliaceae	35	7.31	Tr	2, 3
10	Sissu	*Dalbergia sisso*	Fabaceae	16	3.34	Tr	2, 3, 6
11	Teak/Segun	Tectona grandis	Verbenaceae	12	2.51	Tr	2, 3
12	Neem	*Azadirachta indica*	Meliaceae	11	2.30	Tr	2, 3, 6
13	Shimul/Cotton	*Bombax ceiba*	Malvaceae	14	2.92	Tr	2, 3, 6
Total				479	100.00		

Plant type: Tr: tree, H: herb, Sh: shrub and ST=herb+shrub

Uses: 1: food/fruit, 2: timber, 3: fuel wood, 4: fence, 5: fodder, 6: medicine and 7: others

4.2.1 Species diversity, richness and evenness

In total, 33 different plant species were found belonging 64 homesteads in the surveyed households; total 3032 trees were documented. It was found that Mango tree ranks top of the list (n= 348) of the total plant population followed by coconut (n= 288), banana (n= 287), raintree (n= 276), jackfruit (n= 258), betelnut (n= 192) and mahogany (n= 145) (Table 4.11). Similarly, in crop land agroforestry of 64 surveyed households, 18 different plant species were found from 671 identified plant species. Betelnut ranks top of the list (n= 102) of the total plant population followed by Jackfruit (n= 80), Mango (n= 72) and Banana (n= 64) (Table 4.12). In case of road side agroforestry, 13 different plant species were found from 479 identified plant species. Betelnut ranks top of the list (n= 102) of the total plant population followed by raintree (n= 67), mango (n= 61) and jackfruit (n= 52) (Table 4.13).

Tree species diversity was described by the Shannon Wiener diversity index (H) results 1.314. Diversity Index (SDI), Index of dominance (ID), Species Richness Index (R) and Species Evenness Index (E) were also calculated for homestead, crop land and road side agroforestry and shown on Table 4.14.

Data obtained from homestead Species Diversity Index (0.011) showed lower value than Index of Dominance (0.063) which represents more dominancy of the tree species with more diversity. The calculated value of Species Richness Index and Species Evenness Index of homestead were 9.191 and 0.865, respectively representing more richness of tree species and more evenly the total number of individuals is distributed among all possible tree species (Table 4.14).

Similarly, Species Diversity Index of cropland (0.027) showed lower value than Index of Dominance (0.053) which represents more dominancy of the tree species with more diversity. The calculated value of Species Richness Index and Species Evenness Index of cropland agroforestry were 6.014 and 0.435, respectively representing more richness of tree species and more evenly the total number of individuals is distributed among all possible tree species (Table 4.14).

Again, Species Diversity Index of road side agroforesty (0.027) showed lower more or less same value with Index of Dominance (0.028) which represents less or no dominancy of the tree species with less diversity in road side agroforestry. The calculated value of Species Richness Index and Species Evenness Index of road side agroforestry were 4.477 and 0.374, respectively representing less richness of tree species and less evenly the total number of individuals is distributed among all possible tree species (Table 4.14). Beyene *et al*. (2018) found similar results with the present study and reported among 138 households, 80% were practicing the homestead agroforestry system. The study recorded a total of 22 plant species from 15 families in the sampled home gardens, with 3-5 different species of plants per quadrant. The Shannon diversity index ranged from 2.21 to 2.44. The complex structure of the homestead agroforestry system provides economic benefits and ecological services to the households. Hayat and Kudus (2010) reported among 3414 individual trees representing 120 species, 81 genera, and 31 families in a coastal forest, Malaysia and found species diversity was high with Simpson's index of diversity with a value of 0.96, while Shannon-Weiner index was 5.42.

Table 4.14 Various diversity related parameters for homestead, crop land and road side agroforestry

Parameters	Agroforestry system		
	Homestead	Crop land	Road side
No. of Species= S	33	18	13
No. of individuals= N	3032	671	479
Shannon Winner index of diversity, H= - Σ*Pi* *Ln(*Pi*)	1.314	0.546	0.417
Diversity Index, SDI= S/N	0.011	0.027	0.027
Index of Dominance, ID= Σ(*Pi***Pi*)	0.063	0.053	0.028
Species Richness Index, R= (S-1)/Log N	9.191	6.014	4.477
Species Evenness Index, E= H/Log S	0.865	0.435	0.374

4.2.2 Socioeconomic uses of trees species

Different tree species were observed in the homestead, crop land and road side area. Based on Table 4.11, 4.12 and 4.13; socioeconomic uses of trees species were recorded by accumulation.

From the accumulation of tree species in homestead, 22 fruit/food species (25.58%), 23 fuel wood tree species (26.74%), 19 timber species (22.09%), 8 fodder species (9.30%), 7 medicinal species (8.14%), 4 fence species (4.65%) and 3 others species (3.49%) were found (Table 4.15 and Figure 4.1) in study area.

Table 4.15 Categorization of tree species in homestead, crop land and road side agroforestry according to their socioeconomic uses

Category by uses	Species value in homestead agroforestry	Species value in crop land agroforestry	Species value in road side agroforestry
Food/Fruit	22	12	6
Timber	19	14	13
Fuel Wood	23	12	11
Fence	4	2	1
Fodder	8	4	2
Medicine	7	5	4
Others	3	5	3
Total	86	54	40

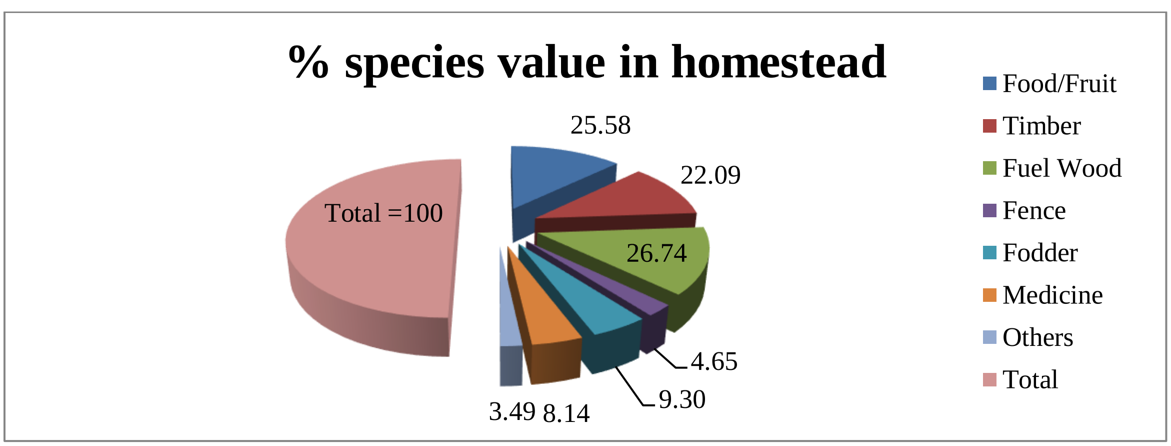

Figure 4.1. Categorization of % tree species in homestead agroforestry according to their socioeconomic uses

From the accumulation of tree species in crop land, 12 fruit/food species (22.22%), 14 timber species (25.93%), 12 fuel wood tree species (22.22%), 5 medicinal species (9.26%), 4 fodder species (7.41%), 2 fence species (3.70%) and 5 others species (9.26%) were found (Table 4.15 and Figure 4.2) in study area.

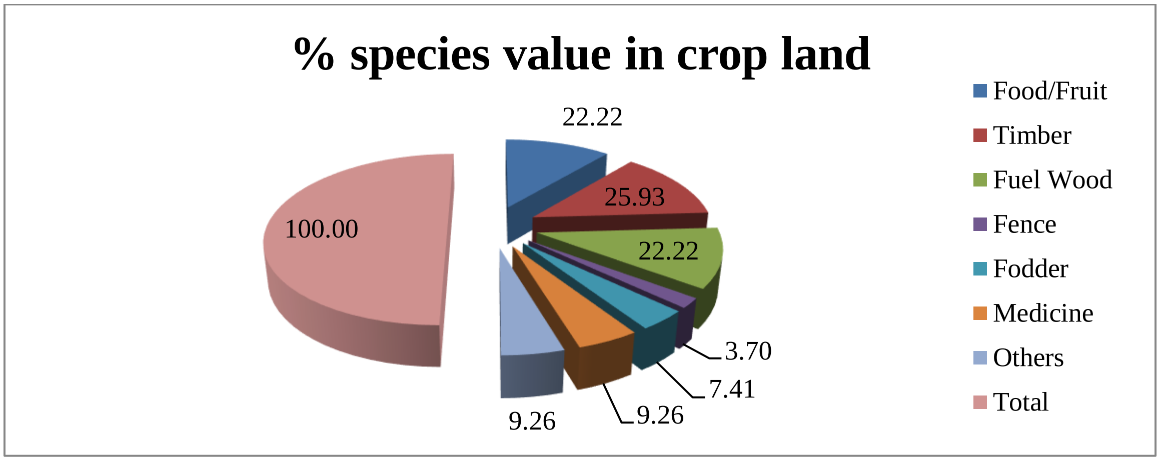

Figure 4.2 Categorization of % tree species in crop land agroforestry according to their socioeconomic uses

From the accumulation of tree species in road side agroforestry, 13 timber species (32.50%), 11 fuel wood tree species (27.50%), 6 fruit/food species (15.00%), 4 medicinal species (10.00%), 2 fodder species (5.00%), 1 fence species (2.50%) and 3 others species (7.50%) were found (Table 4.15 and Figure 4.3) in study area.

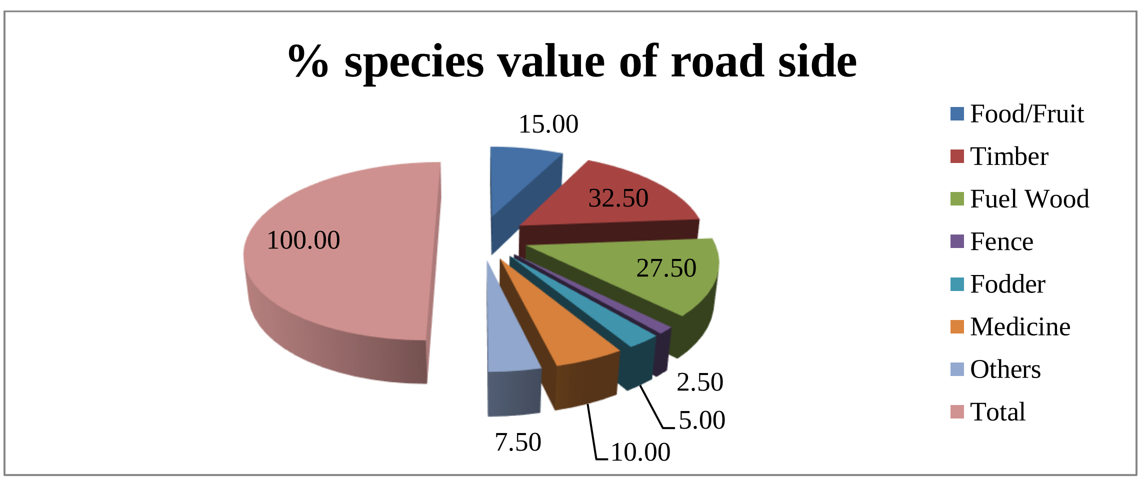

Figure 4.3 Categorization of % tree species in road side agroforestry according to their socioeconomic uses

4.3 Relationship between tree species diversity in homestead, crop land and road side agroforestry with the selected characteristics of the farmers

4.3.1 Relationship between selected characteristics of the farmers and tree species diversity in homestead

Co-efficient of correlation was computed in order to explore the relationship between selected characteristics of the respondents and tree species diversity in homestead agroforestry. As mentioned earlier, 8 (eight) characteristics of respondents were included in independent variables of the study. The characteristics were: age, education, family size, farm size, homestead size, total annual income, livelihood status and changes of livelihood status of farmers through homestead agroforestry. The dependent variable was 'tree species diversity in homestead agroforestry'. To explore the relationships, Pearson's Product Moment Correlation Co-efficient (r) was used to test the null hypothesis concerning the relation between any two variables. Five percent (0.05) and one percent (0.01) level of probability was used as the basis of rejection of a null hypothesis. The relationship between selected characteristics of the respondents and tree species diversity in homestead agroforestry was presented in Table 4.16.

Table 4.16 Computed co-efficient of correlation (r) between dependent variable (Tree species diversity in homestead) and independent variables (age, education, family size, farm size, homestead size, total annual income, livelihood status and changes of livelihood status of the farmers) (N = 64)

Dependent variable	Independent variables	Correlation co-efficient 'r'	Tabulated value	
			5% level	1% level
Tree species diversity in homestead agroforestry	Age	0.101(^{NS})	0.232	0.303
	Education	0.051(^{NS})		
	Family size	-0.099(^{NS})		
	Farm size	0.767(**)		
	Homestead size	0.754(**)		
	Total annual income	0.538(**)		
	Livelihood status of the farmer	0.792(**)		
	Changes of livelihood status of the farmers	0.742(**)		

**Correlation is significant at the 0.01 level NS = Non-significant

4.3.1.1 Relation between age of the farmers and tree species diversity in homestead agroforestry

The relationship between age of respondents and tree species diversity in homestead agroforestry was examined. The co-efficient of correlation between the concerned variables were found to be 0.101 as shown in Table 4.16. The computed value of ‘r’ (0.101) was lower than tabulated value of ‘r’ (0.232) at 5% level of probability. Results revealed that this relationship is non-significant and positively correlated (r = 0.101). So, null hypothesis is accepted.

The findings indicate that the relationship between age and tree species diversity in homestead agroforestry was very feeble but this relation was positive.

4.3.1.2 Relation between educational level of the farmers and tree species diversity in homestead agroforestry

The relationship between education of respondents and tree species diversity in homestead agroforestry was examined. The co-efficient of correlation between the concerned variables were found to be 0.051 as shown in Table 4.16. The computed value of ‘r’ (0.051) was lower than tabulated value of ‘r’ (0.232) at 5% level of probability which indicated that this relationship is non-significant and positively correlated (r = 0.051). So, null hypothesis is accepted.

The growers who had higher education had a tendency to grow various kinds of fruits or timber or other necessary tree species in their homestead. This might be due to their knowledge on usefulness of trees and their importance to human health and environment. Muneer (2008) and Flower *et al*. (2005) also found similar result with the present study and reported that educational level was positively related with the adoption of agroforestry practices.

4.3.1.3 Relation between family size of the farmers and tree species diversity in homestead agroforestry

The relationship between family size of respondents and tree species diversity in homestead agroforestry was examined. The co-efficient of correlation between the concerned variables were found to be -0.099 as shown in Table 4.16. The computed value of ‘r’ (-0.099) was lower than tabulated value of ‘r’ (0.232) at 5% level of probability. Results revealed that this relationship is non-significant and negatively correlated (r = -0.099). So, null hypothesis is accepted.

The findings imply that the family size of the farmers had no significant relationship with the tree species diversity in homestead agroforestry but negative relation indicated that increasing of family size may cause decreasing of tree species diversity.

4.3.1.4 Relation between farm size of the farmers and tree species diversity in homestead agroforestry

The relationship between farm size of respondents and tree species diversity in homestead agroforestry was examined. The co-efficient of correlation between the concerned variables was positive (r=0.767) as shown in Table 4.16. The computed value of ‘r’ (0.767**) was higher than tabulated value of ‘r’ (0.303) at 1% level of probability which indicated that this relationship is highly significant and positively correlated. So, null hypothesis is rejected.

It indicated that there was a strong significant and positive correlation between farm size and tree species diversity in homestead agroforestry. This result also revealed that farm size was strongly correlated with tree species diversity of homestead agroforestry which indicates that if farm size is increased, tree species diversity is also being increased in homestead. Similar result was also by Salam *et al*. (2000), Zeleke (2009) and Dwivedi *et al*. (2009) who studied that when the farm size is large it would encourage agroforestry practices which supported the present findings.

4.3.1.5 Relation between homestead size of the farmers and tree species diversity in homestead agroforestry

The relationship between homestead size of the respondents and tree species diversity in homestead agroforestry was examined. The co-efficient of correlation between the concerned variables was positive (r=0.754) as shown in Table 4.16. The computed value of 'r' (0.754**) was higher than tabulated value of 'r' (0.303) at 1% level of probability which indicated that this relationship is highly significant and positively correlated. So, null hypothesis is rejected.

The researcher concluded that the homestead size of the farmers had highly significant impact on tree species diversity in homestead agroforestry which indicate that tree species diversity in homestead increases with the increasing of homestead size.

4.3.1.6 Relation between total annual income and tree species diversity in homestead agroforestry

The relationship between total annual income of respondents and tree species diversity in homestead agroforestry was examined. The co-efficient of correlation between the concerned variables was positive (r=0.538) as shown in Table 4.16. The computed value of 'r' (0.538**) was higher than tabulated value of 'r' (0.303) at 1% level of probability which indicated that this relationship is highly significant and positively correlated. So, null hypothesis is rejected.

The highly significant and positive relation between annual income and tree species diversity in homestead indicated that tree species diversity in homestead is being increased with the increasing of annual income. Haque (2014) reported that traditional agroforestry in relation to economic and farming conditions of households increased agroforestry practices which led to increase annual incomes which had significant positive impact on farmer's livelihood status and tree species diversity. Similar result was also observed by Pandey (2005) and Dhyani *et al*. (1989).

4.3.1.7 Relation between livelihood status of the respondents and tree species diversity in homestead agroforestry

The relationship between livelihood status of the respondents and tree species diversity in homestead agroforestry was examined. The co-efficient of correlation between the concerned variables was positive (r=0.792) as shown in Table 4.16. The computed value of 'r' (0.792**) was higher than tabulated value of 'r' (0.303) at 1% level of probability which indicated that this relationship is highly significant and positively correlated. So, null hypothesis is rejected.

Highly significant and positive correlation between changes of livelihood status of the farmers and tree species diversity in homestead agroforestry of the farmers indicated that a person having higher livelihood status in his/her homestead was likely to higher positive impact of homestead agroforestry.

4.3.1.8 Relation between changing of livelihood and impact of homestead agroforestry on livelihood status of the farmers

The relationship between changes of livelihood status of the respondents and tree species diversity in homestead agroforestry was observed. The co-efficient of correlation between the concerned variables was positive (r=0.742) as shown in Table 4.16. The computed value of 'r' (0.742**) was higher than tabulated value of 'r' (0.303) at 1% level of probability which indicated that this relationship is highly significant and positively correlated. So, null hypothesis is rejected.

This relation also indicated that tree species diversity in homestead is positively involved to change livelihood status of the farmer. It also means that a person having higher livelihood status in his/her homestead was likely to higher positive impact of homestead agroforestry. Mahato *et al.* (2019) indicated that homestead agroforestry practices led to increase annual income which had significant effect on changing of livelihood status positively. Similar result was also observed by Mourlin (2007).

4.3.2 Relationship between selected characteristics of the farmers and tree species diversity in crop land

Co-efficient of correlation was computed in order to explore the relationship between selected characteristics of the respondents (age, education, family size, farm size, crop land size, total annual income, livelihood status and changes of livelihood status of farmers) and 'tree species diversity in crop land agroforestry'. To explore the relationships, Pearson's Product Moment Correlation Co-efficient (r) was used to test the null hypothesis at five percent (0.05) and one percent (0.01) level of probability. The relationship between selected characteristics of the respondents and tree species diversity in crop land agroforestry was presented in Table 4.17.

Table 4.17 Computed co-efficient of correlation (r) between dependent variable (Tree species diversity in crop land) and independent variables (age, education, family size, farm size, crop land size, total annual income, livelihood status and changes of livelihood status of the farmers) (N = 64)

Dependent variable	Independent variables	Correlation co-efficient 'r'	Tabulated value	
			5% level	1% level
Tree species diversity in crop land agroforestry	Age	0.073(NS)	0.232	0.303
	Education	0.071(NS)		
	Family size	-0.116(NS)		
	Farm size	-0.787(**)		
	Crop land size	-0.765(**)		
	Total annual income	0.601(**)		
	Livelihood status of the farmer	0.797(**)		
	Changes of livelihood status of the farmers	0.763(**)		

**Correlation is significant at the 0.01 level NS = Non-significant

4.3.2.1 Relation between age of the farmers and tree species diversity in crop land agroforestry

The relationship between age of respondents and tree species diversity in crop land agroforestry was examined. The co-efficient of correlation between the concerned variables were found to be 0.073 as shown in Table 4.17. The computed value of ‘r’ (0.073) was lower than tabulated value of ‘r’ (0.232) at 5% level of probability. Results revealed that this relationship is non-significant and positively correlated (r = 0.073). So, null hypothesis is accepted.

Non-significant positive relationship between age of the respondents and tree species diversity in crop land was also found by the findings of Arbuckle (2005) which supported the present study.

4.3.2.2 Relation between educational level of the farmers and tree species diversity in crop land agroforestry

The relationship between education of respondents and tree species diversity in crop land agroforestry was examined. The co-efficient of correlation between the concerned variables was 0.071 as shown in Table 4.17. The computed value of ‘r’ (0.071) was lower than tabulated value of ‘r’ (0.232) at 5% level of probability which indicated that this relationship is non-significant and positively correlated (r = 0.071). So, null hypothesis is accepted.

Dorr (2006) also observed non-significant relation between education of respondents and their crop land agroforestry practices which supported the present findings.

4.3.2.3 Relation between family size of the farmers and tree species diversity in crop land agroforestry

The relationship between family size of respondents and tree species diversity in crop land agroforestry was examined. The co-efficient of correlation between the concerned variables was -0.116 as shown in Table 4.17. The computed value of ‘r’

(-0.116) was lower than tabulated value of ‘r’ (0.232) at 5% level of probability. Results revealed that this relationship is non-significant and negatively correlated (r = -0.116). So, null hypothesis is accepted.

From the findings the researcher concluded that the family size of the farmers had non-significant negative relationship with tree diversity in their crop land which indicated that tree species diversity decreased with the increase of family size.

4.3.2.4 Relation between farm size of the farmers and tree species diversity in crop land agroforestry

The relationship between farm size of respondents and tree species diversity in crop land agroforestry was examined. The co-efficient of correlation between the concerned variables was negative (r=-0.787) as shown in Table 4.17. The computed value of ‘r’ (-0.787**) was higher than tabulated value of ‘r’ (0.303) at 1% level of probability which indicated that this relationship is highly significant and negatively correlated. So, null hypothesis is rejected.

This result indicated that farm size had strong negative correlation with tree species diversity in crop land which indicates that if farm size is increased, tree species diversity is decreased in crop land agroforestry.

4.3.2.5 Relation between crop land size of the farmers and tree species diversity in crop land agroforestry

The relationship between crop land size of the respondents and tree species diversity in crop land agroforestry was examined. The co-efficient of correlation between the concerned variables was negative (r=-0.765) as shown in Table 4.17. The computed value of ‘r’ (0.765**) was higher than tabulated value of ‘r’ (0.303) at 1% level of probability which indicated that this relationship is highly significant and negatively correlated. So, null hypothesis is rejected.

It indicated that there was a highly significant and negative correlation between tree species diversity in crop land and crop land size of the respondents. This relation also indicated that higher crop land size showed lower tree species diversity.

4.3.2.6 Relation between total annual income and tree species diversity in crop land agroforestry

The relationship between total annual income of respondents and tree species diversity in crop land agroforestry was examined. The co-efficient of correlation between the concerned variables was positive (r=0.601) as shown in Table 4.17. The computed value of ‘r’ (0.601**) was higher than tabulated value of ‘r’ (0.303) at 1% level of probability which indicated that this relationship is highly significant and positively correlated. So, null hypothesis is rejected.

Significant and positive correlation between tree species diversity and annual income of the respondents indicated that higher annual income showed positive response on higher tree species diversity.

4.3.2.7 Relation between livelihood status of the respondents and tree species diversity in crop land agroforestry

The relationship between livelihood status of the respondents and tree species diversity in crop land agroforestry was examined. The co-efficient of correlation between the concerned variables was positive (r=0.797) as shown in Table 4.17. The computed value of ‘r’ (0.797**) was higher than tabulated value of ‘r’ (0.303) at 1% level of probability which indicated that this relationship is highly significant and positively correlated. So, null hypothesis is rejected.

It indicated that there was a significant and positive correlation between tree species diversity and livelihood status of the respondents. This relation also indicated that higher livelihood status showed positive response to increase tree species diversity in crop land.

4.3.2.8 Relation between changing of livelihood and impact of crop land agroforestry on livelihood status of the farmers

The relationship between changes of livelihood status of the respondents and tree species diversity in crop land agroforestry was observed. The co-efficient of correlation between the concerned variables was positive (r=0.763) as shown in Table 4.17. The computed value of ‘r’ (0.763**) was higher than tabulated value of ‘r’ (0.303) at 1% level of probability which indicated that this relationship is highly significant and positively correlated. So, null hypothesis is rejected.

Results revealed that there was a highly significant and positive correlation between tree species diversity in crop land and changes of livelihood status of the respondents which indicated that higher tree species diversity in crop land showed positive impact to change their livelihood status.

4.3.3 Relationship between selected characteristics of the farmers and tree species diversity in road side

Co-efficient of correlation was computed in order to explore the relationship between selected characteristics of the respondents (age, education, family size, farm size, crop land size, total annual income, livelihood status and changes of livelihood status of farmers) and ‘tree species diversity in road side agroforestry’. To explore the relationships, Pearson’s Product Moment Correlation Co-efficient (r) was used to test the null hypothesis at five percent (0.05) and one percent (0.01) level of probability. The relationship between selected characteristics of the respondents and tree species diversity in crop land agroforestry was presented in Table 4.18.

Table 4.18 Computed co-efficient of correlation (r) between dependent variable (Tree species diversity in road side) and independent variables (age, education, family size, farm size, total annual income, livelihood status and changes of livelihood status of the farmers) (N = 64)

Dependent variable	Independent variables	Correlation co-efficient ‘r’	Tabulated value	
			5% level	1% level
Tree species diversity in road side agroforestry	Age	-0.105	0.232	0.303
	Education	0.117		
	Family size	-0.158		
	Farm size	-0.712(**)		
	Total annual income	-0.653(**)		
	Livelihood status of the farmer	-0.719(**)		
	Changes of livelihood status of the farmers	-0.738(**)		

**Correlation is significant at the 0.01 level NS = Non-significant

4.3.3.1 Relation between age of the farmers and tree species diversity in road side agroforestry

The relationship between age of respondents and tree species diversity in road side agroforestry was observed. The co-efficient of correlation between the concerned variables was -0.105 as shown in Table 4.18. The computed value of ‘r’ (-0.105) was lower than tabulated value of ‘r’ (0.232) at 5% level of probability. Results revealed that this relationship is non-significant and negatively correlated (r = -0.105). So, null hypothesis is accepted.

The findings indicated that average age of the respondents had no significant impact on tree diversity of road side agroforestry but it was negatively correlated between them.

4.3.3.2 Relation between educational level of the farmers and tree species diversity in road side agroforestry

The relationship between education of respondents and tree species diversity in road side agroforestry was examined. The co-efficient of correlation between the concerned variables was 0.117 as shown in Table 4.18. The computed value of ‘r’ (0.117) was lower than tabulated value of ‘r’ (0.232) at 5% level of probability which indicated that this relationship is non-significant and positively correlated (r = 0.117). So, null hypothesis is accepted.

This result indicated that the respondents who had higher education showed positive response on tree species diversity of road side agroforestry but non-significant correlation was found between them.

4.3.3.3 Relation between family size of the farmers and tree species diversity in road side agroforestry

The relationship between family size of respondents and tree species diversity in road side agroforestry was observed. The co-efficient of correlation between the concerned variables was -0.158 as shown in Table 4.18. The computed value of ‘r’ (-0.158) was lower than tabulated value of ‘r’ (0.232) at 5% level of probability. Results revealed that this relationship is non-significant and negatively correlated (r = -0.158). So, null hypothesis is accepted.

From the findings the researcher concluded that the family size of the farmers had non-significant negative relationship with tree diversity in their crop land which indicated that tree species diversity in road side decreased with the increase of family size.

4.3.3.4 Relation between farm size of the farmers and tree species diversity in road side agroforestry

The relationship between farm size of respondents and tree species diversity in road side agroforestry was examined. The co-efficient of correlation between the concerned variables was negative (r=-0.712) as shown in Table 4.18. The computed value of ‘r’ (-0.712**) was higher than tabulated value of ‘r’ (0.303) at 1% level of probability which indicated that this relationship is highly significant and negatively correlated. So, null hypothesis is rejected.

This result also indicated that farm size had strong negative correlation with tree species diversity in road side which indicates that if farm size is increased, tree species diversity in road side is decreased.

4.3.3.5 Relation between total annual income and tree species diversity in road side agroforestry

The relationship between total annual income of respondents and tree species diversity in road side agroforestry was examined. The co-efficient of correlation between the concerned variables was negative (r=-0.653) as shown in Table 4.18. The computed value of ‘r’ (-0.653**) was higher than tabulated value of ‘r’ (0.303) at 1% level of probability which indicated that this relationship is highly significant and negatively correlated. So, null hypothesis is rejected.

It indicated that there was a highly significant and negative correlation between tree species diversity in road side and annual income of the respondents. This relation also indicated that higher annual income showed lower tree species diversity in road side.

4.3.3.6 Relation between livelihood status of the respondents and tree species diversity in road side agroforestry

The relationship between livelihood status of the respondents and tree species diversity in road side agroforestry was examined. The co-efficient of correlation between the concerned variables was negative (r=-0.719) as shown in Table 4.18. The computed value of ‘r’ (-0.719**) was higher than tabulated value of ‘r’ (0.303) at 1% level of probability which indicated that this relationship is highly significant and negatively correlated. So, null hypothesis is rejected.

The findings indicated that higher livelihood status of the respondents was responsible for lower tree species diversity in road side agroforestry.

4.3.3.7 Relation between changing of livelihood and impact of road side agroforestry on livelihood status of the farmers

The relationship between changes of livelihood status of the respondents and tree species diversity in road side agroforestry was observed. The co-efficient of correlation between the concerned variables was negative (r=-0.738) as shown in Table 4.18. The computed value of ‘r’ (-0.738**) was higher than tabulated value of ‘r’ (0.303) at 1% level of probability which indicated that this relationship is highly significant and negatively correlated. So, null hypothesis is rejected. This result indicated that road side agroforestry had negative impact to change livelihood status of the farmers.

Agroforestry systems can promote biodiversity by providing habitats for various plant and animal species. This biodiversity can enhance ecological balance and contribute to the resilience of farming systems, indirectly benefiting farmers’ livelihoods (Hasan *et al*., 2020). Agroforestry practices can contribute to the sustainable management of natural resources, including water and soil. Proper management of these resources ensures their availability for future generations, safeguarding the long-term livelihoods of farmers. Roadside agroforestry can foster community development by creating employment opportunities, especially during planting and harvesting seasons. It can also encourage community participation in environmental conservation efforts, creating a sense of shared responsibility and pride (Shackleton *et al*., 2008).

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY

The field survey was conducted at randomly selected four villages under two union of Bhola sadar upazila and Daulat Khan upazila in Bhola district, from October 2021 to January, 2022. One village in each union *viz*. Uttar Digholdi from Uttar Dighaldi union, Ilisha from Ilisha union, Uttar Joynagar and Charpata from Daulat Khan Upazila were selected randomly. A total of 64 homestead were identified as representative of the study area. From each village, 20-30 farmers were randomly selected for face-to-face interviewing and data collection. In this study, structured and semi-structured interview schedules as well as several tools of the participatory rural appraisal were used to obtain necessary information. Both descriptive and analytical methods were employed in order to analyze the data. Eight characteristics were considered as independent variables to test the dependent variable; tree species diversity in homestead, crop land and road side agroforestry on livelihood status of the respondents.

The selected independent variables were measured through computing scores based on either scale or appropriate methodology which are followed by previous researchers. Correlation analysis was employed to find out the significant relationship of tree species diversity in homestead, crop land and road side agroforestry on livelihood status of the farmers and socioeconomic characteristics of the selected farmers.

Different tree species were observed in the homestead area as diversified condition. From the accumulation of recorded species in homestead, 22 fruit/food (25.58%), 23 fuel wood (26.74%), 19 timber (22.09%), 8 fodder (9.30%), 7 medicinal (8.14%), 4 fence (4.65%) and 3 others species (3.49%) were found. Regarding the accretion of tree species in crop land, 12 fruit/food species

(22.22%), 14 timber species (25.93%), 12 fuel wood tree species (22.22%), 5 medicinal species (9.26%), 4 fodder species (7.41%), 2 fence species (3.70%) and 5 others species (9.26%) were found in study area. Regarding tree species in road side agroforestry, 13 timber species (32.50%), 11 fuel wood tree species (27.50%), 6 fruit/food species (15.00%), 4 medicinal species (10.00%), 2 fodder species (5.00%), 1 fence species (2.50%) and 3 others species (7.50%) were found in study area.

Considering the abundance of homestead tree species in the study area, the highest percentage of abundance was found for mango (11.48%) followed by coconut (9.50%) and rain tree (9.10%) whereas the minimum percent abundance of tree species (0.40%) was found for both Jalpai and Shimul. In crop land, the abundance of tree species in the study area, the highest percentage of abundance was found for Betelnut (15.20%) followed by Jackfruit (11.92%) and Mango (10.73%) whereas the minimum percent abundance of tree species (0.40%) was found for Teak (1.94%). Regarding crop land agroforestry, the abundance of tree species in the study area, the highest percentage of abundance was found for Koroi (17.54%) followed by Raintree (13.99%) and Mango (12.73%) whereas the minimum percent abundance of tree species (0.40%) was found for Neem (2.30%).

In homestead, Species Diversity Index (0.0109) showed lower value than Index of Dominance (0.063) which represents higher dominancy of the tree species with higher diversity. The calculated value of Species Richness Index and Species Evenness Index was 9.191 and 0.865 respectively which represent the more richness of tree species and more evenly the total number of individuals is distributed among all possible tree species. In crop land, Species Diversity Index (0.027) showed lower value than Index of Dominance (0.053) which represents more dominancy of the tree species with more diversity. Species Richness Index and Species Evenness Index were 6.014 and 0.435, respectively representing more richness of tree species and more evenly the total number of individuals is distributed among all possible tree species. In road side agroforestry, Species Diversity Index (0.027) showed lower more or less same value with Index of Dominance (0.028) which represents less or no dominancy of the tree species with less diversity in road side agroforestry. Species Richness Index and Species Evenness Index were 4.477 and 0.374, respectively representing less richness of tree species and less evenly the total number of individuals is distributed among all possible tree species.

Different types of relationship were shown between independent variables and tree species diversity in homestead, crop land and road side agroforestry. The study also revealed that farmer's age and education had non-significant positive relationship with tree species diversity but family size had non-significant negative relationship with the concerned variable in homestead agroforestry. Similarly, farm size, homestead size, total annual income, livelihood status of the farmers and changes of livelihood status of the farmers were highly significant and positively correlated with the tree species diversity in homestead.

Again, age and education had non-significant positive relationship with tree species diversity but family size had non-significant negative relationship with the concerned variable in crop land agroforestry. Similarly, farm size and crop land size were highly significant and negatively correlated with the tree species diversity in crop land agroforestry but total annual income, livelihood status of the farmers and changes of livelihood status of the farmers were highly significant and positively correlated with the tree species diversity in crop land agroforestry. Furthermore, age and family size had non-significant negative relationship with tree species diversity but education had non-significant positive relationship with the concerned variable in road side agroforestry. Similarly, farm size, total annual income, livelihood status of the farmers and changes of livelihood status of the farmers were highly significant and negatively correlated with the tree species diversity in road side agroforestry.

CONCLUSION

In homestead, a total of 3032 trees, representing 33 genera and 19 families were recorded while in crop land, 671 trees representing 18 genera and 12 families were recorded whereas in road side, 479 trees, representing 13 genera and 7 families were recorded in the 64 household survey of study area.

Farm size, homestead size, crop land size, total annual income, livelihood status of the farmers and changes of livelihood of the farmers due to homestead, crop land and road side agroforestry had significant impact on tree species diversity which influenced the livelihood status of the farmers while diversity analysis of tree species indicated higher dominancy of the tree species with higher diversity in different agroforestry systems of the study area.

Fruit/food, timber and fuel wood were mostly diversified compared to fodder, medicinal plants, fence and others species in different agroforestry system. Species Diversity Index showed lower value than Index of Dominance in homestead and crop land agroforestry which represents more dominancy of the tree species with more diversity. The impact of homestead, crop land and road side agroforestry on species diversity related to livelihood status of the farmers and socioeconomic characteristics is beyond of question as trees are the integral part of nature as well as human society. Most of the trees, in homestead, crop land and road sides are not planted in a planned way. There is enough scope to improve productivity in such agroforestry system by replacing the existing tree species with the improved and/or exotic ones, planting trees in planned ways and improving management practices with modern agroforestry technologies for maximization of income through homestead, crop land and road side agroforestry by increasing diversity of trees. To increase tree plantation in the homesteads, crop land and road side and their appropriate management, including intercropping practices should be the strategy for enhancing tree species diversity of the study area which may keep positive impact on livelihood status of the farmers.

RECOMMENDATIONS

In spite of the immense scope and prospects of the homestead, crop land and road side, no systemic program has so far been under-taken to improve their livelihood status through homestead, crop land and road side agroforestry using existing species diversity. In order to improve prevailing socioeconomic condition regarding livelihood status of the respondents in the study area, comprehensive initiatives are needed to be taken by the government organizations (GOs), non-government organizations (NGOs), development agencies, as well as rural society. By considering the overall aspect of this present study the following points can be recommended:

i. This type of research findings will be helpful to facilitate similar research in other district/area in Bangladesh. In this regard if all district/area carried out under similar research then it will represent the overall livelihood status as well as pattern of tree species diversity in Bangladesh.
ii. To meet growing demand for tree products, many fruits and forest species can grow voluntarily without any management from the seeds sources of mother trees.
iii. Increasing awareness, facilitating need-based training and improving and encouraging of homestead plantings become a vital activity as such activities already common and practiced by most of farmers.
iv. Utilizing labor, family income earners and cultivable land, generally, designing appropriate management strategies and approaches should be required for domestication and integration of improved trees by diversifying and intensifying a wide range of priority species.

REFERENCES

Adedayo, A.G. and Oluronke, S. (2014). Farmer's perception and adoption of agroforestry practices in osun state, Nigeria. *Forest Res*. **3**: 127.

Ahmed, M. and Ali, M.H. (2003). Agroforestry-environmental linkages and different tree species in homegarden. Lecture note prepared for the Agroforestry Training Workshop held during BARC, Dhaka. pp. 51-58

Alam, M. K., and Masum, M. A. (2005). Homestead forest resources and their management in the flood-prone areas of Bangladesh. *J. Small-scale Forest Econ. Manag. Policy*. **4**(2): 161-174.

Ali, M.S. and Chaturvedi, O.P. (2008). Pattern and constraints of adoption of agroforestry systems in north Bihar. *J. Trop. Forestry*, **24** (1/2):10-15.

Aryal, K.P. and Kerkhoff. (2008). The right to practice shifting cultivation as a traditional occupation in Nepal: A case study to apply ILO Conventions Nos. 111 (Employment and Occupation) and 169 (Indigenous and Tribal Peoples). *ILO Publisher*. pp. 127-131.

Asian Development Bank (ADB). (1993). Bangladesh: Forestry Master Plan Study. Manila: Asian Development Bank.

Baig, M.B. and Ehrenreich, J.H. (2014). The potential, prospects and problems of agroforestry in Pakistan. *Agroforestry Res. Dev*. **6**: 22-28.

Bangladesh Bureau of Statistics (BBS). (2020). Statistical Yearbook of Bangladesh 2020. Dhaka: Bangladesh Bureau of Statistics.

Barua, S.K., Alam, G.M.M., and Borkotoky, K. (2015). Agroforestry practices for sustainable development of hilly regions in Bangladesh. *J. Agric. Ecol. Res. Int*. **3**(1): 16-27.

Baul, T.K., Peuly, T.A., Nandi, R., Kar, S. and Mohiuddin, M. (2021). Composition of homestead forests and their contribution to local livelihoods and environment: A study focused on Bandarban hill district, Bangladesh. *Trees, For. Peo*. **5**: 100–117. https://doi.org/10.1016/j.tfp. 2021.100117.

Beyene, M., Mohammed, M. and Nigatu, L. (2018). Plant species diversity and structure in homegarden agroforestry systems of Bulen District, North-Western Ethiopia. *Int. J. Environ. Sci. Nat. Res*. **15**(4): 1-11.

Brady, N.C. (1996). Alternatives to slash-and –Burn. *Agric. Ecosyst. Environ*. **58**: 3-11.

Chambers, R. and Conway, G. (1991). Sustainable Rural Livelihoods: Practical Concepts for the 21st Century. Retrieved February **3:** 51-63. http://www.smallstock.info/reference/IDS/dp296.pdf

Chavan, S.B., Keerthika, A., Dhyani, S.K., Handa, A.K., Newaj, R. and Rajarajan, K. (2015). National Agroforestry Policy in India. *J. fruit. Curr. Sci*. **108**(10): 1826-34.

Chowdhury, M.Q.K., Rahman, M.S., Rahman, M.A., and Bokhtiar, S.M. (2018). Agroforestry systems in Bangladesh: An overview of practices, potentials, and challenges. *J. Forest. Res*. **29**(3): 775-788.

Das, L., Mishra, S.K. and N.C. Rath. (2008). Tribal livelihood and gender empowerment inrice-based farming system. *Oryza*, **45**(2): 142-146.

Dhakal, S. (2000). An anthropological perspective on shifting cultivation: a case study of Khoriya cultivation in the Arun valley of Eastern Nepal. Occasional paper on Sociology and Anthropology. Department of Sociology and Anthropology. Tribhuvan University, Nepal.

Dhyani, S.K. and Chauhan, D.S. (1989). Evaluation of crops in relation to shade in densities of Khasi pine (Pinus kesiya).Progress report Agroforestry Division, ICAR Research Complex for N.E.H. Region, Shillong.

Dwivedi, P., Rathore, C.S. and Dubey, Y. (2009). Ecological benefits of urban forestry: The case of Kerwa Forest Area (KFA), Bhopal, India. *Appl. Geog*. **29**(2): 194-200.

Elasha, B.O., Elhassan, N.G., Ahmed, H. and Zakieldin, S. (2005). Sustainable livelihoodapproach for assessing community resilience to climate change: case studiesfrom Sudan. AIACC Working Paper No.17, Higher Council for Environmentand Natural Resources, Sudan. August 2005.

Flower, T.E., Valdivia, C. and Dorr, H.R. (2005). Habitus and Interest in Agroforestry Practices in Missouri. Selected Paper Prepared and Presented at the American Agricultural Economic Association Annual Meeting. pp. 24-27.

Forestry Master Plan. (1992). Ministry of Environment and Forests - 1992. Forestry master plan – Land use, Asian Development Bank.

Gangadharappa, N.R., Sajeev, M.V., Ganesamoorthi, S., Nagesha, G., Ibrahim, S., Ranganatha, A.D. and Reddy, M.V.S. (2005). Exploratory study on economic andmarketing aspects of Agroforestry and their implications in Dharwad and Belgaum districts, Karnataka. *My Forest*, **41**(2): 107-119.

Garrity, D., Akinnifesi, F.K., Ajayi, O.C., Weldesemayat, S.G., Mowo, J.G. and Kalinganire, A. (2010). Evergreen agriculture: a robust approach to sustainable food security in Africa. *Food Security*. **2**(3): 197-214.

Garrity, D.P. (2006). Science-based agroforestry and the Millenium Development Goals. In D.P. Garrity, A. Okono, M. Grayson and S. Parrott (eds.) World

Agroforestry into the Future, Nairobi, Kenya: World Agroforestry Centre, ICRAF. pp. 3-8.

Haque, M. A., and Amin, M. R. (2016). The Role of Multipurpose Tree Species in Rural Livelihood Improvement in Bangladesh. *European J. Sust. Dev*. **5**(3): 423-432.

Haque, M.A.R. (2014). Socio-economic impacts of homestead agroforestry on local people livelihood in Aditmary upazilla of Lalmonirhat district.

Hayat, M.S.A. and Kudus, K.A. (2010) Assessment of plant species diversity at Pasir Tengkorak Forest Reserve, Langkawi Island, Malaysia. *J. Agril. Sci*. **2**: 1.

Henry, M., Tittonell, P., Manlay, R. J., Bernoux, M., Albrecht, A. and Vanlauwe, B. (2009). Biodiversity, carbon stocks and sequestration potential in aboveground biomassin smallholder farming systems of western Kenya. *Agr. Ecosyst. Environ*. **129** (1): 238–252.

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

Huxley, P.A. (1985). The tree/crop interface or simplifying the biological/ environmental study of mixed cropping agroforestry systems. *Agroforest. Syst*., **3**: 251-266.

Iiyama, M., Neufeldt, H., Dobie, P., Njenga, M., Ndegwa, G., Jamnadass, R. and Gotz, M. (2016). Towards sustainable agricultural landscapes in the drylands of sub-Saharan Africa: The case of agroforestry in the Central Rift Valley of Ethiopia. *J. Land Degrad. Dev*. **27**(2): 252-263.

IPCC (2013). Fourth assessment report: climate change 2013 (AR5) from IPCC website (http://ipcc.ch/publications_and_data/publications_and_data_reports.shtml/).

Islam, K.K., Jose, S., Tani, M., Hyakumura, K., Krott, M. and Sato, N. (2015). Does actor power impede outcomes in participatory agroforestry approach? Evidence from Sal forests area, Bangladesh. *Agrofor. Syst*. **89**: 885–899.

Islam, K.K., Rahman, G.M.M., Fujiwara, T. and Sato, N. (2013). People's participation in forest conservation and livelihoods improvement: experience from a forestry project in Bangladesh. *Int. J. Biodivers. Sci. Ecosyst. Serv. Manag*. **9**: 30–43. https://doi.org/ 10.1080/21513732.2012.748692.

Islam, M.S., and Amin, M.R. (2015). Agroforestry as a sustainable land use system in Bangladesh: A review. *Agric. Forest. Fisher.* **4**(6): 301-307.

Islam, M.W. (2013). Comparative Financial Analysis of Agroforestry Land Uses: Cropland Agroforestry, Homestead Agroforestry and Annual Cropping in Rajshahi District, Lambert Academic Publishing, Germany.

Jacob, V.J. and Alles, W.S. (1987). The Kandyan gardens of Sri Lanka. *Agroforest. Syst.* **5**: 123-137. 10.1007/BF00047517.

Jensen, M. (1995). Woodfuel Productivity of Agroforestry Systems in Asia. A Review of current Knowledge. GCP/RAS/154/NET, Field Doumentment No. 45. Regional Wood Energy Development Programme in Asia. FAO, Bangkok. p. 40.

Johnson-Welch, C., Alemu, B., Msaki, T.P., Sengendo, M., Kigutha, H. and Wolff, A. (2000). Improving Household Food Security: Institutions, Gender and Integrated Approaches. Davis CA, USA: Paper prepared for the

Broadening Access and Strengthening Input Market Systems (BASIS) Collaborative Research Support Project (CRSP).

Jose, S. (2009). Agroforestry for ecosystem services and environmental benefits. *Agroforest. Syst*. **76**: 1-10. https://doi.org/10.1007/s10457-009-9229-7

Kareemulla, K., Reddy, K.S., Rama-Rao, C.A., Kumar, S. and Venkateswarlu, B. (2009). Soil and water conservation works through National Rural Employment Guarantee Scheme (NREGS) in Andhra Pradesh– an analysis of livelihood impact. *Agric. Econ. Res. Rev*. **22** (3): 443-450.

Kerkhoff, E. and Sharma, E. (2006). Debating shifting cultivation in the Eastern Himalays: Farmers' innovations as lessons for Policy. ICIMOD, Kathmandu, Nepal.

Khalid, F. and Bora, P. (2000). Changes in quality of pineapple fruit at different times. *J. Food Sci. Tech*. **26**(1): 51-52.

Kindu, M. (2001). Practices, constraints and agroforestry interventions in Yeku watershed Northeastern Ethiopi. *EJNR*. **3**(1):161-178.

Lakra, V. and Sah, R.B. (2008). Agroforestry strategies of tribal and non-tribal farmers in Jharkhand. Directorate of Research, Birsa Agricultural University, Ranchi, Jharkhand, India.

Leakey, R. (2014). The role of trees in agroecology and sustainable agriculture in the tropics. *Ann. Rev. of Phytopathol*. **52**: 113–133.

Mahapatra, I.C. (2010). Manual on integrated farming systems, Proceeding of launching workshop of integrated farming systems during Group meeting of scientist of AICRP on IFS held at Thiruanantpuram, Kerala, 6-9 March, 2010.

Mahato, R.K., Sah, R.B., Oraon, P.R. and Singh, B.K. (2019). Impact of Agroforestry Practices on Livelihood Improvement of Farmers in Ichak Block of Hazaribagh District, Jharkhand, India. *Int. J. Curr. Microbiol. Appl. Sci*. **8**(1): 702-12.

Mannan, M.A., Haque, M.M. and Islam, M.S. (2013). Plant Biodiversity in the Hoar Homesteads of Bangladesh, *IRJALS*. **2**(5): 2.

Maroyi, A. (2009). Traditional homegardens and rural livelihoods in Nhema communal area, Zimbabwe. *J. Human Ecol*. **28**(2): 109-116.

Mattssona, E., Ostwalda, M., Nissankac, S.P. and Pushpakumara, D.K.N.G. (2014). Quantification of carbon stock and tree diversity of homegardens in a dry zone area of Moneragala district, Sri Lanka. Division of Physical Resource Theory, Department of Energy and Environment, Chalmers University of Technology, 412 96 Göteborg, Sweden.

Mattsson. E., Ostwald.M. Nissanka. S.P. and Pushpakumara. D.K.N.G. (2015). Quantification of carbon stock and tree diversity of homesteads in a dry zone area of Moneragala district, Sri Lanka. *J. Agroforest. Syst*. **89**(3): 435-445.

Mesele-Negash. (2002). Socio-economic Aspects of Farmers Eucalyptus Plant Practice in the Enset-coffee Based Agroforestry System of Sidama, Ethiopia: The case of Awassa and shebedino District Msc Thesis Swedish University, Uppsala (Sweden).

Mishra, Y.D., Bhardwaj, N. and Kashyap, S.K. (2007). Joint Forest Management (JFM) forsustainable development: Astudy of Kumaun region of Uttaranchal. *Int. J. Trop. Agric*., **25**(1/2): 5-13.

Mohankumar, B. and Miah, M.G. (2004). Agroforestry for Asian food security. In: Book of abstract, World Congress of Agroforestry, 27 June-2 July, Florida, USA.

Mourlin, K. (2007). NREGA - A key to sustainable rural development: An empirical evidence from Betul district. *Vikas Vani J*. **1**(4): 14-23.

Muneer, S.E.T. (2008). Factors Affecting Adoption of Agroforestry Farming System as a Mean for Sustainable Agricultural Development and Environment Conservation in Arid Areas of Northern Kordofan State, Sudan. *Saudi J. Biol. Sci*. **15**(1): 137-145.

Mushtaq, T., Sood, K.K. and Raina, N.S. (2012). Species preferences for fuelwood in Shiwalik Himalayas-Implications for agroforestry plantations. *Indian J. Hill Farming*. **25**(2):18-21.

Nair, P.K.R. (2010). Agroforestry: A Decade of Development. *Agroforestry Syst.* **79**(3): 187-192.

Nair, P.K.R. (1990). An introduction to Agroforestry: pp 13-155, ICRAF/Kluwers Academic Publishers, Dordrecht, The Netherlands.

Pandey, A.K. (1999). Socio-economic profile of tribal and non-tribal farmers in the tribal setting of Bihar. Rural India, October, 1999. pp. 67-72.

Poschen, P. (1986). An evaluation of the Acacia albida-based agroforestry practices in the Hararghe highlands of Eastern Ethiopia, *Agroforest. Syst*. **4**: 129-143.

Prasad, R., Kumar, D., Pandey, V.K. and Prasad, S. (2014). Agroforestry: a pathway for sustainable land use and climate change mitigation. *Agroforest. Syst.* **88**(6): 851-872.

Prins, K. (2000). Conservation and poverty alleviation - The view and practice of the poor. CIAT Poverty Alleviation Workshop Paper. http://ciatlibrary. ciat.cgiar.org/paper_pobreza/071.pdf, download 2008/11/14. Project, Kathmandu, Nepal.

Rahman, M.S., Uddin, M.N., Rahman, M.S. and Rana, M.P. (2018). Impact of agroforestry practices on household income: A case study of Bangladesh. *J. Forestry Res*., **29**(3): 789-800.

Rahman, S.A., Groot, W.T. and Snelder, D.J. (2008). Exploring the Agroforestry Adoption Gap: Financial and Socioeconomics of Litchi-Based Agroforestry by Smallholders in Rajshahi (Bangladesh). In: Nair, P.K.R., Snelder, D.J. and Lasco, R.D. (eds), Smallholder Tree Growing for Rural Development and Environmental Services: lessons from Asia *J. Adv. Agroforest*. **5**: 227-44.

Ray, G.L., Bhattacharya, AK. and Maity, S.K. (996). A study in forestry extension. Naya Prakash, Calcutta.

Reddy, E.V. (2011). Constraints in marketing of agroforestry produce in India. *The Indian Forester*. **137**(6): 669-677.

Regmi, B.R., Subedi, A., Aryal, K.P. and Tamang, B.B. (2005). Shifting cultivation systems and innovations in Nepal. LIBIRD (Local initiatives for Biodiversity Research and Development): Pokhara, Nepal. pp. 73-77.

Saka, A.R., Bundreson, W.T., Mbekeani, Y. and Itinu, O.A. (1990). Planting and implementing agroforestry. For small-holderfarmers in Malawi, In: Budd *et al*. Planting for agroforestry. *Elsevier Appl. Sci. London*. p. 137.

Salam, M.A., Noguchi, T. and Moike, M. (2000). Understanding why farmers plant trees in the homestead agroforestry in Bangladesh. *Agroforest. Syst*. **50**: 77-93.

Sampson, M. (1992). Soil physiology, tree structure and biomass of a Javanese agroforestry. *Agroforest. Syst*. **24**: 134-144.

Sanchez, P.A., Palm, C.A., and Buol, S.W. (1997). Fertility capability soil classification: A tool to help assess soil quality in the tropics. *J. Geoderma*. **77**(3-4): 283-295.

Schroth, G., da-Fonseca, G.A.B., Harvey, C.A., Gascon, C., Vasconcelos, H.L. and Izac, A.M.N. (2004). Agroforestry and biodiversity conservation in tropical landscapes. Island Press, Washington, DC.

Shackleton, C. M., Shackleton, S. E., Buiten, E., and Bird, N. (2008). The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy Econ*. **10**(5): 286-295.

Sharma, S.K. (2007). Development of fruit tree based agroforestry systems for degraded lands – a review. *Range Mgmt. Agroforest*. **30**(2): 98-103.

Singh, S.K. (2005). An appraisal of livelihoods in rural Jharkhand. Praxis-Institute for participatory practices, Ranchi, Jharkhand.

Singh, G.B. (1987). Agroforestry in the Indian subcontinent:past, present and future. In:Steppler HA and Nair PKR (eds), Agroforestry: a decade of development. ICRAF, Nairobi, Kenya. pp.117-138.

Snelder, D.J. and Lasco, R.D. (2008). Smallholder Tree Growing in South and Southeast Asia. In: Nair, P.K.R., Snelder, D.J. and Lasco, R.D (eds.), Smallholder Tree Growing for Rural Development and Environmental Services: lessons from Asia. Advances in Agroforestry, Springer Science, Leiden. *The Netherlands*. **5**: 3- 36

Sood, K.K., Najiar, C. and Singh, K.A. (2005). Household level domestic fuel consumption, need hypothesis and agroforestry adoption: Lessons from Eastern Himalaya. *Indian J. Agroforest*. **35**(2): 67-72.

Tanaka, S. and Fujiwara, K. (2014). Roadside Agroforestry: Past, Present, and Future. In Agroforestry for Sustainable Land-Use Fundamental Research and Modelling with Emphasis on Temperate and Mediterranean Applications. *J. Springer*. pp. 59-73.

Tanga, C.M., Kimathi, M., Vanlauwe, B. and Merckx, R. (2014). Enhancing soil fertility and plant nutrient availability in African smallholder farms through integrated nutrient management: Evidence from field experiments. *J. Agric. Ecosyst. Environ*. **184**: 51-58.

Tewari, D.N. (1995). Agroforestry for increased productivity, sustainability and poverty alleviation. International Book Distributors, Dehradun, India.

Uddin, M.B., Uddin, M.S., Rahman, M.S. and Haque, M.S. (2002). Role of homestead plantations in biodiversity conservation and rural livelihood development in Bangladesh. *J. Sust. Forest.* **15**(3-4): 117-136.

Vishwanatham, M.K., Samra, J.S. and Sharma, A.R. (1998). Biomass production of Silvipasture Systems on gravelly lands of Doon valley. BulleteinNo.T-39/D-26. *CSWCRTI Dehradun*. pp. 68-69.

World Bank. (2004). Sustaining forests: a development strategy. Retrieved from http://siteresources. worldbank.org/ INTFORESTS/ Resources/ Sustaining Forests.pdf XV, No. 1. Oxfords University Press, New York, USA. pp. 26-33.

Yamane, Y. (1967). Mathematical formulae for sample size determination. *American J. Indust. Busin. Manag*. **11**(5): 1-11.

Zeleke, A.W. (2009). Status of traditional agroforestry and its future potential development as buffer zone agroforestry for the natural forest conservation in Burkitu Pesant Association, Oromia, Ethiopia. M.Sc. Thesis, Wondogent College of Forestry and Natural Resources, Hawassa University, Wondo Genet, Ethiopia. p. 84.

Zomer, R.J., Trabucco, A., Coe, R. and Place, F. (2009). Trees on farm: analysis of global extent and geographical patterns of agroforestry. Working Paper 89. Nairobi: World Agroforestry Centre (ICRAF).

APPENDICES

Appendix I: Questionnaire on interview schedule used in this study to assess farmer's information

English version of an interview schedule
Department of Agroforestry and Environmental Science
Sher-e-Bangla Agricultural University
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Interview schedule for data collection of the research

IMPACT OF AGROFORESTRY SYSTEM ON FARMERS LIVELIHOOD OF BHOLA SADAR AND DAULAT KHAN UPAZILA IN BHOLA DISTRICT

(The interview schedule is entitled for a research study)

Serial no. :

Date:

Upazila:

Union:

Village:

"Please answer the following questions"

1. Age

How old are you? .... Years

2. Education

Please state your level of education

a. Can read and write ( )
b. Can sign only ( )
c. I read up to …………… class
d. I've passed ………..…class

3. Occupation

a. Main occupation……………………..

b. Others………………………………

4. Family member

Sl. No.	Sex	Number
1	Male	
2	Female	
Total		

5. Farm size: Please furnish information on your land ownership

Sl. No.	Pattern of ownership of land	Area	
		Local unit	Hectare
1.	Homestead		
2.	Own land under own cultivation		
3.	Land taken from others on borga		
4.	Land given to others on borga		
5.	Land taken from others on lease		
6.	Others (specify)		
Total			

6. Homestead size

Sl. No.	Description	Area	
		Local unit	Hectare
1.	Homestead		
2.	Own land under own cultivation		
3.	Land taken from others on borga		
4.	Land given to others on borga		
5.	Land taken from others on lease		
6.	Others (specify)		
7.	Homestead		
Total			

6. Crop land size

Sl. No.	Description	Area	
		Local unit	Hectare
1.	Own land under own cultivation		
2.	Land taken from others on borga		
3.	Land given to others on borga		
4.	Land taken from others on lease		
5.	Others (specify)		
Total			

7. Total annual income (000)

Sl. No.	Source of Income	Amount(Tk. '000')
1.	Agriculture	
2.	Non-agricultural	
3.	Labourer	
4.	Business	
5.	Transport and communication	
6.	Service	
7.	Construction	
8.	Religious Service	
9.	Rent and remittance	
10.	Others	
Total		

9. Livelihood status: Impact of livelihood status regarding homestead agroforestry

Sl. No.	Livelihood indicators	Evaluation scale	Score (0-3)
1.	Water facilities	0 - 3	
2.	Sanitation	0 - 3	
3.	Educational status	0 - 3	
4.	Freedom in cash expenditure	0 - 3	
5.	Participation in social activities	0 - 3	
6.	Food availability	0 - 3	
7.	Health situation	0 - 3	
8.	Housing condition	0 - 3	
9.	Clothing status	0 - 3	
10.	Self transportation	0 - 3	
Total			

10. Changing of livelihood status: Changing of livelihood of farmers through homestead agroforestry

Sl. No.	**Livelihood indicators**	**Changes of livelihood status compared to previous situation (changing scoring; 0-3)**				**Total**
		No (0)	Low (1)	Medium (2)	High (3)	
1.	Changes in food habit					
2.	Changes in clothing					
3.	Changes in residence					
4.	Changes in education					
5.	Changes in health issue					
6.	Changes in sanitation					
	Total					

11. Tree species in homestead, crop land and road side: Please list of tree species in your homestead, crop land and road side

Sl. No.	**Name of tree specie**	**No.**	**Uses**
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.	**Others**		
Total			

Thank you giving me your valuable time

Appendix II. Tabulation of collected data through survey using prepared questionnaire

Sl. No.	Age	Education	Family size	Farm size (ha)	Homstead size (ha)	Crop land size (ha)	Annual income (000)	Livelihood status (Scoring)	Changing of livelihood status	Species diversity in Homestead	Species diversity in crop land	Species diversity in road side
1	58	10	2	1	0.11	0.89	45	15	7	1.22	2.57	2.60
2	31	5	3	2.3	0.3	2	72	21	13	0.50	1.00	1.00
3	45	12	3	0.21	0.03	0.18	18	10	5	2.75	6.00	4.33
4	37	12	7	1.5	0.2	1.3	57	17	8	1.57	3.60	6.50
5	24	8	3	0.64	0.12	0.52	36	13	6	1.43	3.60	6.50
6	39	9	6	2.4	0.4	2	136	22	14	0.22	0.43	0.37
7	25	16	2	3	0.24	2.76	168	24	15	0.32	0.67	0.62
8	55	7	4	0.8	0.09	0.71	42	14	7	3.00	6.00	6.50
9	24	6	5	1.3	0.14	1.16	32	15	7	2.20	4.50	6.50
10	28	10	4	1.4	0.17	1.23	48	16	8	2.20	3.60	6.50
11	45	12	5	0.84	0.1	0.74	30	11	7	2.06	4.50	6.50
12	51	8	3	1.63	0.2	1.43	76	19	14	0.69	1.80	2.17
13	59	9	4	2.4	0.25	2.15	204	21	14	0.43	1.20	1.44
14	26	6	8	1.5	0.2	1.3	102	20	13	0.49	1.38	1.44
15	46	10	5	0.32	0.04	0.28	21	8	4	4.71	6.00	6.50
16	52	11	3	1.2	0.2	1	45	15	8	0.79	1.80	2.17
17	27	7	9	0.9	0.16	0.74	32	14	8	1.65	3.60	4.33
18	53	0	3	3.12	0.52	2.6	306	26	16	0.18	0.35	0.29
19	26	8	5	1.7	0.18	1.52	80	19	9	1.32	4.50	6.50
20	64	0	4	0.88	0.11	0.77	35	12	5	3.30	6.00	6.50

21	24	10	6	2.14	0.32	1.82	200	22	13	0.40	1.38	1.44
22	37	12	8	2.7	0.3	2.4	204	22	13	0.45	1.80	2.17
23	39	7	3	0.6	0.08	0.52	38	14	8	4.71	6.00	6.50
24	26	6	5	2.3	0.18	2.12	98	19	13	1.32	3.00	6.50
25	62	0	5	1.8	0.24	1.56	78	18	9	0.49	1.29	1.30
26	44	7	3	0.45	0.08	0.37	72	13	6	4.71	9.00	6.50
27	28	12	4	1.4	0.2	1.2	92	18	10	0.83	3.00	4.33
28	48	8	6	1.6	0.19	1.41	82	12	7	0.87	2.57	4.33
29	29	10	2	0.75	0.14	0.61	48	14	7	2.20	4.50	6.50
30	40	11	7	1.8	0.2	1.6	90	15	8	1.00	3.00	4.33
31	63	9	4	3	0.33	2.67	300	23	14	0.31	0.95	0.87
32	30	12	5	2.7	0.4	2.3	266	24	15	0.22	0.55	0.52
33	42	14	3	1.33	0.22	1.11	52	16	9	0.89	3.00	6.50
34	44	10	8	0.1	0.01	0.09	32	10	6	6.60	9.00	4.33
35	47	9	3	1.52	0.15	1.37	50	17	10	1.50	3.60	6.50
36	26	13	5	1.24	0.19	1.05	66	19	13	0.69	1.64	1.86
37	45	3	9	2.48	0.36	2.12	118	18	11	0.24	0.67	0.59
38	48	7	6	1	0.11	0.89	45	17	10	1.57	6.00	6.50
39	44	12	5	1.3	0.18	1.12	76	18	12	1.22	3.00	3.25
40	26	8	2	0.86	0.12	0.74	57	13	6	2.06	3.00	4.33
41	34	3	9	3.2	0.48	2.72	296	24	14	0.20	0.44	0.39
42	43	6	5	1.8	0.15	1.65	125	18	10	1.38	3.60	4.33
43	65	8	5	1.12	0.14	0.98	124	15	8	2.06	4.50	6.50
44	47	12	7	0.63	0.05	0.58	24	9	5	5.50	9.00	6.50
45	42	7	3	2.2	0.18	2.02	100	19	12	1.57	6.00	4.33
46	24	7	6	1.2	0.12	1.08	37	14	8	2.54	6.00	6.50

47	42	12	8	1.6	0.18	1.42	28	14	7	0.79	1.80	2.17
48	59	6	5	2.1	0.28	1.82	120	22	13	0.46	1.38	2.17
49	42	0	5	2.8	0.42	2.38	164	25	15	0.27	0.69	0.68
50	48	9	6	3	0.45	2.55	274	25	15	0.22	0.56	0.48
51	61	12	4	1.2	0.14	1.06	30	14	8	1.38	4.50	4.33
52	65	8	4	0.5	0.03	0.47	28	9	5	4.71	6.00	4.33
53	25	7	2	1.8	0.2	1.6	107	18	10	0.69	2.25	2.60
54	44	7	3	1.5	0.13	1.37	35	16	10	2.06	3.00	4.33
55	62	10	3	2.4	0.45	1.95	118	23	14	0.27	0.60	0.54
56	37	6	8	1.7	0.2	1.5	142	17	11	1.22	3.60	4.33
57	39	5	3	1.2	0.13	1.07	42	12	6	2.75	6.00	4.33
58	49	8	5	1.6	0.2	1.4	65	16	9	1.03	3.60	4.33
59	48	10	3	2.5	0.22	2.28	109	23	14	0.72	2.57	3.25
60	54	12	4	1.5	0.15	1.35	80	20	13	0.92	3.00	3.25
61	64	9	9	1.75	0.25	1.5	87	19	13	0.53	1.38	1.30
62	55	9	2	0.32	0.02	0.3	60	8	5	5.50	9.00	6.50
63	50	4	3	1.05	0.2	0.85	92	18	12	0.83	2.57	2.60
64	25	10	2	1.1	0.18	0.92	30	15	8	1.57	3.00	3.25

Appendix III. Analytical output of collecting data using SPSS statistical program

Items	Age	Education	Family size	Farm size (ha)	Homestead size (ha)	Crop land size (ha)	Total annual income (000)	Livelihood status	Changing livelihood status
Mean	42.672	8.328	4.703	1.561	0.199	1.362	93.219	16.984	9.891
Std. Deviation	12.754	3.400	2.021	0.788	0.115	0.6872	73.247	4.513	3.310
Range	41.000	16.000	7.000	3.100	0.510	2.67	288.000	18.000	12.000
Minimum	24.000	0.000	2.000	0.100	0.010	0.09	18.000	8.000	4.000
Maximum	65.000	16.000	9.000	3.200	0.520	2.76	306.000	26.000	16.000

Appendix IV. Correlation matrix regarding correlation between independent variables (age, education, family size, farm size, total annual income, livelihood status and changes of livelihood status of the farmers) and tree species diversity in homestead

Category	Age	Education	Family size	Farm size	Homestead size	Total annual income	Livelihood status of the farmer	Changes of livelihood status of the farmers	Tree species diversity in homestead agroforestry
Age	1	-0.149	-0.064	-0.04	-0.017	0.04	-0.08	-0.031	0.101
Education		1	-0.076	-0.173	-0.243	-0.174	-0.143	-0.091	0.051
Family size			1	0.176	0.206	0.173	0.083	0.111	-0.099
Farm size				1	.892(**)	.830(**)	.908(**)	.861(**)	.767(**)
Homestead size					1	.814(**)	.870(**)	.810(**)	.754(**)
Total annual income						1	.790(**)	.754(**)	.538(**)
Livelihood status of the farmer							1	.954(**)	.792(**)
Changes of livelihood status of the farmers								1	.742(**)
Tree species diversity in homestead agroforestry									1

Appendix V. Correlation matrix regarding correlation between independent variables (age, education, family size, farm size, total annual income, livelihood status and changes of livelihood status of the farmers) and tree species diversity in crop land

Category	Age	Education	Family size	Farm size	Crop land size	Total annual income	Livelihood status of the farmer	Changes of livelihood status of the farmers	Tree species diversity in crop land agroforestry
Age	1	-0.149	-0.064	-0.04	-0.043	0.04	-0.08	-0.031	0.073
Education		1	-0.076	-0.173	-0.158	-0.174	-0.143	-0.091	0.073
Family size			1	0.176	0.168	0.173	0.083	0.111	-0.116
Farm size				1	.997(**)	.830(**)	.908(**)	.861(**)	.787(**)
Crop land size					1	.815(**)	.895(**)	.851(**)	.765(**)
Total annual income						1	.790(**)	.754(**)	.601(**)
Livelihood status of the farmer							1	.954(**)	.797(**)
Changes of livelihood status of the farmers								1	.763(**)
Tree species diversity in crop land agroforestry									1

Appendix VI. Correlation matrix regarding correlation between independent variables (age, education, family size, farm size, total annual income, livelihood status and changes of livelihood status of the farmers) and tree species diversity in road side

Category	Age	Education	Family size	Farm size	Total annual income	Livelihood status of the farmer	Changes of livelihood status of the farmers	Tree species diversity in road side agroforestry
Age	1	-0.149	-0.064	-0.04	0.04	-0.08	-0.031	-0.105
Education		1	-0.076	-0.173	-0.174	-0.143	-0.091	0.117
Family size			1	0.176	0.173	0.083	0.111	-0.158
Farm size				1	.830(**)	.908(**)	.861(**)	.712(**)
Total annual income					1	.790(**)	.754(**)	.653(**)
Livelihood status of the farmer						1	.954(**)	.719(**)
Changes of livelihood status of the farmers							1	.738(**)
Tree species diversity in road side agroforestry								1