COST- BENEFIT ANALYSIS OF DIFFERENT AGROFORESTRY SYSTEMS OF KAHAROLE UPAZILA OF DINAJPUR DISTRICT

A THESIS

BY

PARAMA RANI ROY

Registration No. 1605447

Session: 2016

Thesis Semester: July-December, 2017

MASTER OF SCIENCE (M.S.)

IN

AGROFORESTRY AND ENVIRONMENT

DEPARTMENT OF AGROFORESTRY AND ENVIRONMENT

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

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Submitted to the Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur in Partial fulfillment of the requirements for the degree of

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Approved as to style and contents by

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DECEMBER 2017

DEDICATED
TO MY
BELOVED PARENTS

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The Authoress

COST- BENEFIT ANALYSIS OF DIFFERENT AGROFORESTRY SYSTEMS OF KAHAROLE UPAZILA OF DINAJPUR DISTRICT

ABSTRACT

A study was carried out to evaluate the benefits and costs of homestead, cropland and orchard agroforestry systems of Kaharole Upazila under Dinajpur District of Bangladesh. An extensive field survey and measurements were conducted during July 2017 to January 2018 at different unions and villages of Kaharole Upazila. A multistage random sampling procedure was followed in this study to select the survey area. A pre-structured questionnaire was used for collecting the benefits and costs data. A total of 60 agroforestry practices including 20 homesteads, 20 orchards and 20 croplands were evaluated for cost and benefit analysis. Normality test of income and cost data was done by Kolmogorov-Smirnov Test. Three years costs and income data were collected from the field survey. Linear regression equation was obtained by using trend line in MS Excel to forecast seven years of gross income and production cost data of different agroforestry systems. Benefit-cost ratio (BCR) was determined upto ten years. Results of the production cost analysis showed that significantly maximum production cost was in orchard agroforestry system (Tk. 98987 per ha.) followed by cropland (Tk. 90238 per ha.) and minimum in homestead system (Tk. 10854 per ha.) in the 1st year. But production cost decreasing trend was recorded in the successive years in all the systems. In case of gross income analysis showed that though initial income was significantly lower in orchard agroforestry followed by cropland and homestead but after tenth year higher income was found in orchard agroforestry system (Tk. 564758 per ha.) followed by cropland (Tk. 251914 per ha) and homestead ((Tk. 234234 per ha) agroforestry system. However the net income indicated that orchard agroforestry system was financially more profitable than cropland and homestead agroforestry systems, but the benefit-cost ratio (BCR) was higher in homestead as well as cropland agroforestry systems and lower in orchard agroforestry system. The findings suggest that orchard agroforestry as well as homestead systems are economically more profitable than cropland agroforestry system.

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CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

Bangladesh is one of the most densely populated countries of the world having agro based economy which situated in the North-Eastern port of south Asia with a tropical to sub-tropical climate. Now the population of Bangladesh is 16 crore in an area of 147570 sq. Kilometers (BBS, 2015). This excessive population creates pressure on the cultivated land. Bangladesh is a land scarce country where per capita cultivated land is only 12.5 decimals. Each year, nearly 1.94 million peoples are added to its population of about 122 million (FAO, 2012). Deforestation is a major problem in northern part of Bangladesh. Deforestation is nothing but a prime cause of soil erosion and land degradation (Barbier 1998). Due to rapid growth of population, people migrate to forest area and are encroaching and cultivation food crops. The total forest land area of the country covers about 13.36% of the land area (BBS, 2013). Conversely, actual tree coverage is less than 10.20% (FAO, 2011). However according to forest master plan and surveys by multilateral donor agencies a total of 76900 ha or 6% of the country land mass has actual tree coverage. But to enjoy benefit of nature, we should have at least 25% of our land covered with forest.

Lundgren and Raintree, (1982) stated that agroforestry is a collective name of all land use systems and technologies where woody perennials are deliberately grown on the same land management units as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence.

Agroforestry is an age-old practice but modern concept is now being developed. It is a sustainable management system for land that combines agricultural crops, trees, forest plants and/or animals simultaneously or sequentially, and applies management practices that are compatible with the cultural patterns of the local population (Raintree, 1997).

Hafizul (2007) stated that well planned and well managed agroforestry can play an important role in solving acute problem of food, fuel, fodder, soil fertility and ecology. He also concluded that agroforestry system practices are highly profitable and play significant role in improving the economic status of the farmers.

Nahar (2009) observed that the average size of the homestead in the study area was 0.12 ha which increased with the increased of farm size. The homestead production system

was found to be poor due to management practices. It was also observed that the major problem of planting new trees in the homestead was damaged by grazing animals (80%) followed by unavailability of space (61%); damaged by flood (55%), Jack of good quality seeds (64%) and insect pest infestation (56%). There is enough scope it improve productivity in the homestead by replacing the existing tree species with the improved and/or exotic ones, planting trees in planned ways and improving management practices.

Hossain and Bari (1996) reported that generally wives (39.8%) were more involved than husbands (34.8%) in the application of manure (decomposed leaves, household wastes, cowdung, etc.) and fertilizers to homestead vegetable gardens. However, this pattern was prominent amongst landless and marginal farm categories but husbands were more involved in soil fertility management than wives on small, medium and large farms.

Cropland Agroforestry is a traditional and or innovative land use system where different tree species grow naturally or planted on agricultural lands and are purposely retained and maintained by the farmers for different household utilities, products and also for cash income in Bangladesh (Chakraborty *et al.,* 2015, Abedin and Quddus, 1991, Abedin *et al.,* 1987). Various patterns of cropland agroforestry systems are practiced in different agro-ecological regions of Bangladesh which reflects biophysical and social variations (Shams, 2013). Trees are planted on the borders or within the field, systemically or at irregular intervals, usually with crops such as rice, wheat, pulse, jute, oilseed, sugarcane, vegetables and others, and farmers also grow shade-tolerant crops such as turmeric, ginger and aroid when trees have high canopy coverage (Miah *et al.,* 2002).

Cropland agroforestry system provides enough food, timber, fodder, fruit, fuel wood, construction materials, raw materials and other products for forest-based small-scale enterprises and other cottage industries (Hasan *et al.,* 1997)

Orchard agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. It combines shrubs and trees in agricultural and forestry technologies to create more diverse, productive, profitable, healthy, ecologically sound, and sustainable land-use systems (USDA National Agroforestry Center, 2015).

Economic evaluation is the process of systematic identification, measurement and valuation of the inputs and outcomes of two alternative activities, and the subsequent comparative analysis of these. The purpose of economic evaluation is to identify the best course of action, based on the evidence available (Drummond *et al.,* 2005).

Cost benefit analysis involves measuring costs and benefits in commensurate terms, usually monetary. Welfare economics shows that under certain conditions any net excess of monetary benefits over costs represents the gain in welfare by society. Cost benefit analysis makes it possible to determine, firstly, whether an individual intervention offers an overall net welfare gain and, secondly, how the welfare gain from that intervention compares with that from alternative interventions. Increased use of interventions with the greatest net gain will increase efficiency. By valuing all costs and benefits in the same units, cost benefit analysis compares diverse interventions using the net benefit criterion. Cost benefit analysis thus simultaneously addresses issues of productive and allocative efficiency.

While research on climate change implications of different agroforestry systems is well-advanced (Montagnini and Nair, 2004; Albrecht and Kandji, 2003; Varchot *et al.,* 2007), there are only few instances of such attempts in home garden literature .Similar trends are also observed in northern part of Bangladesh. A number of studies on homestead agroforestry are available (Alam and Furukawa, 2008; Rahman *et al.,* 2005(a); Rahman, *et al.,* 2006(a); Rahman *et al.,* 2006(b); Leuschner and Khaleque, 1987), but all were conducted in regions where climate and agro-ecology is very different from the northwestern region. Kabir and Webb (2008) studied home garden biodiversity in the southern Bangladesh where soil is salty and climate is relatively humid. Similarly, Rahman *et al.,* 2005(b) explored the role of homestead agroforestry in household economy in central Bangladesh.

But, unfortunately due to lack of baseline information from the northern regions, we still do not have a full understanding of the role of homestead agroforestry or a similar land use system in mitigation of and adaptation to dry climate (Alam, 2008). Hence, considering that there is a lack of realistic information and knowledge on the structural characteristics and economic analysis of different practices of home gardens, cropland agroforestry and orchard agroforestry in northern region. This study provides valuable information of economic benefit of different practices for homestead agroforestry,

cropland and orchard agroforestry. The researcher tried to evaluate cost, income, net income and benefit cost ratio, and management techniques, utilization and farmers' preferences and attitudes for promotion and development of home gardens, cropland agroforestry, and orchard agroforestry. By gathering baseline data on the composition of homestead agro-forestry, cropland and orchard agroforestry hopefully it will help policy makers and practitioners as well as farmers to improve productivity and mitigation strategies in this study area.

Therefore, it is necessary to assess the agroforestry system that is suited with the present condition and what type of effects done on the respondents. So the researcher the must give importance to evaluate the effect of agroforestry to changes of the respondent socioeconomic condition. Considering the above circumstances, the present study was undertaken taking the following research questions:

a) What is the present status of homestead, cropland and orchard agroforestry practices in the study area?
b) Whether the homestead, cropland and orchard agroforestry practices are same economic return?
c) Which is the most profitable practice among the three?

Objectives of the study

The research work was conducted with the following objectives:

1. To identify different agroforestry systems in Kaharole upazila at Dinajpur district.
2. To assess demographic status of the farmers who are practicing agroforestry in Kaharole upazila.
3. To enumerate production cost and benefits of different agroforestry systems in Kaharole upazila.
4. To identify the best profitable agroforestry systems in Kaharole upazila.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

This chapter presents a brief review of the past studies and opinions of researchers having relation to this investigation which were gathered from text books, journals, dissertations, reports and other form of publications.

2.1 Concept of agroforestry

Filius, (1982) observed that design and evaluation of agroforestry systems requires thorough knowledge of relationships between agriculture and forestry. Complementary and supplementary relationships mainly resulting from biological factors make agroforestry an efficient system of land use. Agroforestry can be an appropriate technology in areas with fragile ecosystems and subsistence farming.

Cole, (2010) stated that agroforestry practices offer many advantages such as crop and livestock protection, soil and stream conservation and protection, diversification of agricultural revenues through the production of timber and non-timber forest products, promotion of biodiversity, landscape enhancement and carbon sequestration.

Somarriba, (1992); Garrett *et al.* (2000); and Dupraz *et al.* (2005) stated that Agroforestry is a perspective way of biomass production that combines simultaneous growing of woody plants with agricultural crops on the same area for different purposes. Agroforestry is the combination of agricultural and forestry technologies to create integrated, diverse and productive land use system in which two or more plant species interact, one of the species being perennial and having a woody consistency.

Lundgren and Raintree, (1982) stated that agroforestry is a collective name of all land use systems and technologies where woody perennials are deliberately grown on the same land management units as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence.

Leakey (1996) reported that this represents a concept of integrated land use that combines elements of agriculture and forestry in a sustainable production system. The emphasis here is on managing rather than reducing complexity. Agroforestry uses the natural woodland ecosystem as a model to create “a dynamic, ecologically-based, natural resources management system”.

Nair (1991) observed that key characteristics that distinguish agroforestry systems from agriculture and forestry include greater structural and functional complexity, an emphasis on multipurpose trees, and the production of multiple outputs balanced with protection of the resource base.

According to ICRAF (1993) 'agroforestry is a collective name for all land-use systems and technologies, where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management unit as agricultural crops and/or animals, either in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components'.

Raintree (1997) observed that agroforestry is an age-old practice but modern concept is now being developed. It is a sustainable management system for land that combines agricultural crops, trees, forest plants and/or animals simultaneously or sequentially, and applies management practices that are compatible with the cultural patterns of the local population.

Feldhake *et al.* (2008) agroforestry provides opportunities to increase the value of total production through marketing of multiple products from a given unit of land.

Interactions between the tree and crop/livestock components can be positive, negative or neutral. In the former case complementarity results in increased capture of a limiting resource, and greater total production than if the two components had been grown separately. Conversely, negative interaction, when the two components overlap in their resource use, can lead to competition and hence lower productivity than if the components are grown separately. Where there are no direct interactions between system components, the net effect of combining them is neutral.

Jose (2004) reported that interactions between the tree and crop/livestock components can be positive, negative or neutral. In the former case complementarity results in increased capture of a limiting resource, and greater total production than if the two components had been grown separately. Conversely, negative interaction, when the two components overlap in their resource use, can lead to competition and hence lower productivity than if the components are grown separately. Where there are no direct interactions between system components, the net effect of combining them is neutral.

McAdam (2008) stated that agroforestry systems can provide recreational opportunities that can benefit the general public as well as the landowner. Activities such as hunting, fishing, mountain biking, equestrianism and rural tourism can diversify income for farmers, while the public can benefit from improved health and enjoyment from agroforestry through sports and wildlife watching.

Jose (2009) reported that agroforestry can increase the amount of carbon sequestered compared to monocultures of crops or pasture due to the incorporation of trees and shrubs

Schroeder, (1994) stated that woody perennials store a significant amount of carbon in above ground biomass and also contribute to belowground carbon sequestration in soils. Average carbon storage by agroforestry systems is estimated at 9, 21, 50 and 63 Mg C ha-1 in semiarid, sub humid, humid and temperate regions respectively, with higher rates in temperate regions reflecting longer rotations and longer-term storage.

Gordon and Newman (1997) stated that agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In AF systems there are both ecological and economical interactions between the different components.

Hafizul (2007) stated that well planned and well managed agroforestry can play an important role in solving acute problem of food, fuel, fodder, soil fertility and ecology. He also concluded that agroforestry system practices are highly profitable and play significant role in improving the economic status of the farmers.

Partha (2009) has reported that CARE assisted Road side agroforestry program bring a change in the socioeconomic status of the participants through increasing income generating capacity and using the waste land of the road side. The program also improved the overall environmental condition and prevented the soil erosion.

2.2 Concept of homestead agroforestry

Awal *et al.* (2000) observed that homestead fruit and vegetable practices earned substantial income for all categories of farmers. The women were involved in the household decision making process to a greater extent. The evidence was more

spectacular in aspects like family planning, education of children, poultry rearing, plantation of fruits and vegetables and marriages of sons and daughters.

According to Bangladesh Economic Survey (2015) Homestead agroforestry is an age old practice and an integral part of traditional farming system in Bangladesh. Agriculture is very important for the economy of Bangladesh. It contributes about 15.33 percent to the gross domestic products (GDP) and about 66 percent of employment of labor forces.

According to FAO (1986) homestead is one of the most elaborate systems of indigenous agroforestry found most often in tropical and sub-tropical areas where subsistence land use systems predominate.

Fernandes and Nair (1990) observed that homestead represent a land-use systems involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual house, the whole crop -tree-animal unit being intensively managed by family labor.

Miah and Hossain (2001) conducted a study of Narsingdi district of Bangladesh about indigenous knowledge on homestead forestry and they explored that the households were engaged to tree planting programs (*Azadirachta indica* with *Artocarpus heterophyllus*), forestry products and services, women involvement, spacing of plantation, tending and cultural operations and problems in the homestead forestry. The study also reveals some important indigenous management techniques.

Moontasir *et al.* (2009) studied about different agroforestry practices for socio-economic improvement of the farmers in Comilla Sadar. The findings revealed that majority (40.75%) of the farmers belong to medium category possessed medium (21-30 trees) number of diversified tree species. The majority 33.33% of the farmers had low attitude regarding contribution of diversified tree species for their socioeconomic condition, where 25.92% was found to large category respectively. Within 40 different tree species, the high relative density of the study area was Mango (21.34%), Betel-nut (12.89%) and Jackfruit (8.73%) respectively.

Nahar (2009) observed that the average size of the homestead in the study area was 0.12 ha which increased with the increased of farm size. The homestead production system was found to be poor due to management practices. It was also observed that the major

problem of planting new trees in the homestead was damaged by grazing animals (80%) followed by unavailability of space (61%); damaged by flood (55%), Jack of good quality seeds (64%) and insect pest infestation (56%). There is enough scope it improve productivity in the homestead by replacing the existing tree species with the improved and/or exotic ones, planting trees in planned ways and improving management practices.

Das and Das (2005) stated that home gardens are traditional agroforestry systems with complex structure and multiple functions. To understand the system, the socio-economic and biophysical aspects of home gardens in Dorgakona village, Barak Valley, North East India were studied. Since home gardens are also important sites for in situ on-far in conservation, the role of the rural people in the management and preservation of biodiversity in their traditional home gardening systems will be examined. The home garden size ranges from 0.02 to 1.20 ha with an average of 0.30 ha. The total number of species encountered in the home gardens will be 122, with fruits as the dominant use component. The home gardens are the sites of conservation of a large diversity of plants both wild and domesticated, because of their uses to the households. Thus the home gardens were found to be complex systems with plant diversity conserved through their use.

Hossain and Bari (1996) reported that generally wives (39.8%) were more involved than husbands (34.8%) in the application of manure (decomposed leaves, household wastes, cowdung, etc.) and fertilizers to homestead vegetable gardens. However, this pattern was prominent amongst landless and marginal farm categories but husbands were more involved in soil fertility management than wives on small, medium and large farms.

2.3 Concept of cropland agroforestry

Cropland Agroforestry (CAF) is a traditional and or innovative land use system where different tree species grow naturally or planted on agricultural lands and are purposely retained and maintained by the farmers for different household utilities, products and also for cash income in Bangladesh (Chakraborty *et al.,* 2015, Abedin and Quddus, 1991, Abedin *et al.,* 1987). Various patterns of cropland agroforestry systems are practiced in different agro-ecological regions of Bangladesh which reflects biophysical and social variations (Shams, 2013). Trees are planted on the borders or within the field, systemically or at irregular intervals, usually with crops such as rice, wheat, pulse, jute, oilseed, sugarcane, vegetables and others, and farmers also grow shade-tolerant crops

such as turmeric, ginger and aroid when trees have high canopy coverage (Miah *et al.,* 2002).

Cropland agroforestry system provides enough food, timber, fodder, fruit, fuel wood, construction materials, raw materials and other products for forest-based small-scale enterprises and other cottage industries (Hasan *et al.,* 1997)

Trees in crop fields work as insurance in case of sudden crop failure or to support crops against environmental hazards and also to provide extra income from trees. Moreover, if there is a failure in one crop, the other crops would supplement the deficit. So, CAF is largely evolved with sustainability concerns - resiliency, diversity, and avoiding negative side effects in mind (Brooks *et al.,* 1995)

2.4 Concept of orchard agroforestry

Orchard agroforestry is a branch of agroforestry which is situated far from homestead. In orchard agroforestry large trees are deeply nourished. Here specific spacing is maintained. In this system crops are grown under tree at initial stage. Gradually tree canopies, branches, and tree height etc. are increasing. As a result crop yield are decreasing. After a few years tree gives more yield which result more income from trees.

According to USDA National Agroforestry Center (2015) orchard agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. It combines shrubs and trees in agricultural and forestry technologies to create more diverse, productive, profitable, healthy, ecologically sound, and sustainable land-use systems.

SHED (1988) stated that agroforestry means a mixed cultivation of trees and crops (fruit trees, timber trees, bamboo, vegetables, spices, medicinal plants etc.) grown on the same plot of land. Trees provide food and essential nutrients1 with their fruits. They provide fuel wood for cooking, timber for construction, but also medicinal plants and other important non-timber products (honey, spices, mushrooms, etc.). They are important sources of revenue for the farmers, play a crucial role in diminishing the impacts of natural disasters and provide a number of other environmental services. In Bangladesh, demographic pressure, urbanization and industrialization continue to reduce the already meagre forest coverage: to date, actual forest coverage in Bangladesh is less than 7 percent.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

3.1 Area

Among the 13 upazilas of Dinajpur districts, Kaharol Upazila was selected to get basic information about the existing traditional and modern agroforestry system practiced in the area, socio economic conditions of the farmers, input cost and output benefits from the results of the survey, data of targeted cropland, homestead and orchards kept for further analysis.

3.2 Geographical location of Kaharole Upazila

Kaharole is an upazila of Dinajpur District in the Division of Rangpur, Bangladesh. Kaharole is located in between 25°44' and 25°53' north latitudes and in between 88°30' and 89°43' east longitudes. It is bounded by birganj upazila on the north, Dinajpur sadar and biral upazilas on south, khansama and Dinajpur Sadar upazilas on the east, bochaganj upazila on the west.

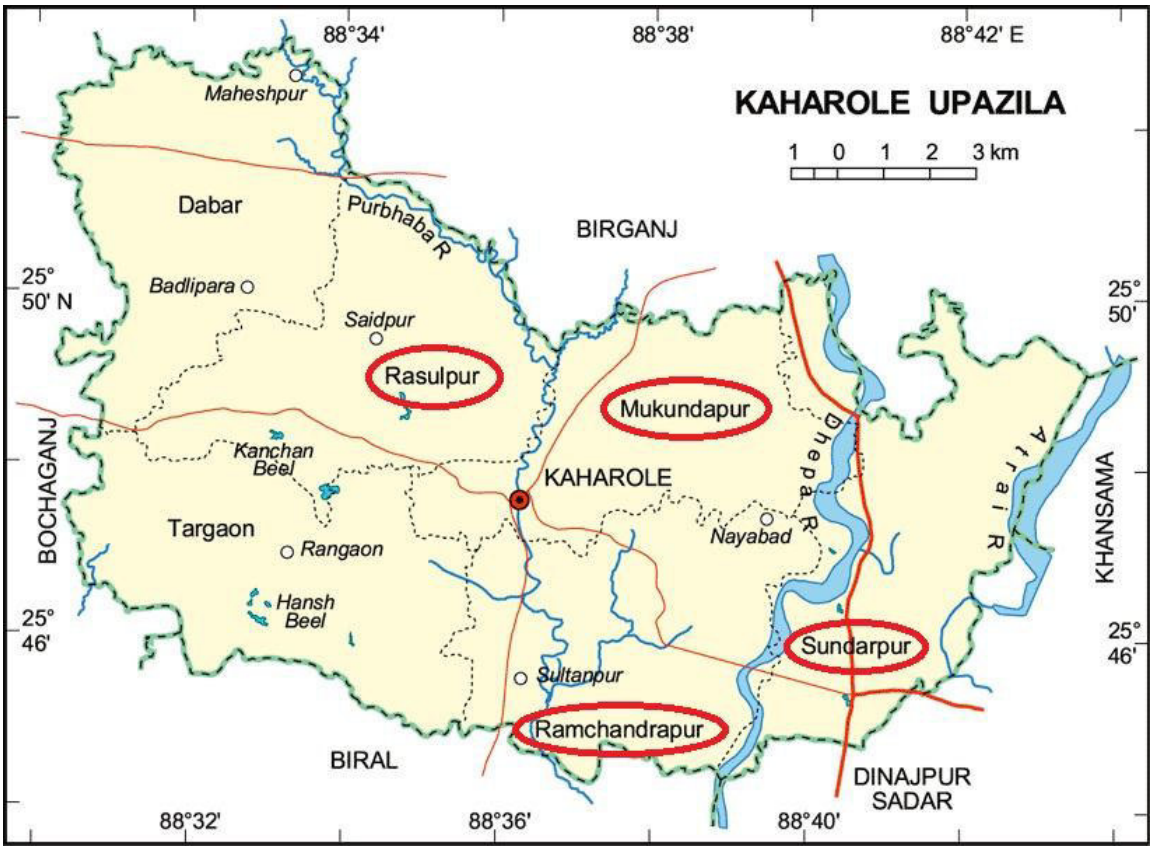

Figure 1: Map of Kaharole Upazila of Dinajpur district showing the study area (Source: Banglapedia)

3.3 Demographic description of the study area

Population Total 137315; male 70088, female 67227; Muslim 73309, Hindu 60641, Buddhist 1280, Christian 46 and others 2039. Indigenous community such as santal belongs to this upazila. *Literacy rate and educational institutions* Average literacy 40.9%; male 48.3%, female 33.1%. Educational institutions: college 5, secondary school 46, primary school 143, madrasa 20. Noted educational institutions: Kaharole College (1983), Kaharole Women's Degree College (1997), Purba Mallikpur HM College (1990), Kaharole High School (1940), Isanpur School (1953), Ramchandrapur School (1962), Kaharole Bazar Fazil Madrasa (1985).

Table 1. Shows the number of unions, villages and population status at a glance.

Kaharole Upazila								
Municipality	Union	Mouza	Village	Population		Density (per sq km)	Literacy rate	
				Urban	Rural		Urban	Rural
-	6	153	152	6524	130791	668	49.3	40.4

(Source: Bangladesh Population Census 2001, Bangladesh Bureau of Statistics.)

3.4 Sampling design

This study follows a multistage random sampling procedure. Firstly, Dinajpur district (locally called zila) is purposively selected from the northern region of Bangladesh. Consequently, out of 13 upazilas (sub-districts) in the Dinajpur district, Kaharole Upazila is randomly selected. Out of 6 unions of Kaharole upazila, a total of four unions are selected randomly taking 5 villages and from each villages 3 cropland/ homestead/orchard will be selected. From the four selected unions, a total of 20 villages are selected randomly taking 5 villages from each union.

3.5 Sampling

The study area at Kaharole upazila was conducted at the following unions and villages:

Sl No.	Union	Village	Systems	Total practices
1	2 No. Rasulpur	Rasulpur, Moheshpur, Baharpur, Nalapur, Chandipur, etc.	Homestead, Orchards, Cropland	Mango based, Litchi based, Mahagony ucalyptus based, Mixed homegarden
2	3. No. Mukundapur	Mukundapur, Dohonda, Pouria, etc.	Homestead, Orchards, Cropland	Mango based, Litchi based, Mahagony ucalyptus based, Guava based, Mixed homegarden
3	5 No. Sundorpur	Gornurpur, Purboshadipur, Helenchakuri, Sundorpur, etc.	Homestead, Orchards, Cropland	Mango based, Litchi based, Mahagony ucalyptus based, Guava based, Jujube based, Mixed homegarden
4	6 No. Ramchandapur	Nayabad, Poromeshoripur, Mitrabati,Saranja, Ishanpur, etc.	Homestead, Orchards, Cropland	Mango based, Litchi based, Mahagony ucalyptus based,

3.6 Method of data collection

3.6.1 Questionnaire survey

A set of preliminary survey schedule were used to collect the information. The survey schedule was carefully designed keeping the objectives of the study in view. The schedule contained both open and closed form questions (Appendix). Very easy, simple, direct questions and different scales were used to obtain information. About 60 survey schedule were filled up taking information from farmer.

3.6.2 Period of data collection

To get valid and pertinent information the researcher made all possible effort to explain the purpose of the study to the respondents. The researcher administered the interview schedule personally to the respondents. Rapport was established with the respondent's though informal discussion regarding objectives of the interview. Co-operation was obtained from respondents during data collection. Data were collected from July 2017 to January 2018.

3.7 Variables of the study

3.7.1 Independent variables

The followings viz. respondent age, respondent sex, level of education, family size, farm size, plant to plant spacing, row to row spacing, tree age, agroforestry species composition were used as independent variables of the study.

3.7.2 Dependent variable

The following viz. production cost, gross income, net income, benefit cost ratio were used as dependent variables of the study.

3.7.3 Family size

Family size classified in four categories. They are lower (1-3), medium (4-6), higher (7-8) and large (>8).

3.7.4 Respondent age

Respondent age classified as two categories. Category I belongs to age group (15-35) and category II belongs to age group (16-64).

3.7.5 Level of education

Level of education of agroforestry growers classified as four categories. They are primary, secondary, higher secondary and tertiary. Primary category belongs to (1-5), secondary (6-10), higher secondary (11-12) and tertiary (13+).

3.7.6 Respondent Sex

Respondent sex were categorized in two groups. They were male and female.

3.7.7 Farm size

Farm size classified in four categories. They are lower, medium, higher and large. Low category belongs to low (upto 0.060), medium (0.061-0.100), high (0.101-0.160) and large (upto 0.161+) ha.

3.7.8 Plant to plant spacing

Plant to plant spacing classified in four categories. They are irregular spacing, PP spacing (1-7), PP spacing (8-13) and PP spacing (14 to upward).

3.7.9 Row to row spacing

Row to row spacing classified in four categories. They are irregular spacing, RR spacing (1-7), RR spacing (8-13) and RR spacing (14 to upward).

3.7.10 Tree age category

Tree age category classified in four categories. Category 1 belongs to age group (1-2), category 2 age group (3-5), category 3 age group (6-10) and category 4 age group (10+).

3.7.11 Year

Three years data were collected from the field of agroforestry growers and rest seven years data were forecasted with the help of trend line.

3.8 Measurement of dependent variable

3.8.1 Production cost

Annual production cost of a farmer was measured in taka on the basis of his total yearly production cost (land preparation cost, labour cost etc.). Data were collected three years production cost from the respondent and forecasted rest seven years production cost with the help of regression line equation.

3.8.2 Gross Income

Gross income in the monetary value of total product and by-product. Annual gross income of a farmer was measured in taka on the basis of his total yearly earnings from cropland, orchard and homestead agroforestry systems. We were collected three years gross income from the respondent and forecasted rest seven years gross income with the help of regression line equation.

3.8.3 Net income

Net income usually means the profit of the enterprises. Net income was calculated by deducting the total cost of production from the gross income. Net income was analyzed from the collected three years production cost and gross income and rest seven years were a forecasted from the regression equation.

3.8.4 Benefit cost ratio

Benefit – cost ratio is the ratio of gross income with total cost of production. Benefit cost ratio was analyzed from the collected three years production cost and gross income and rest seven years were forecasted from the regression equation.

3.9 Data Collection and analysis

An intensive household survey is carried out with a questionnaire to fulfill the objectives of the study during July 2017 to January 2018. Besides, transect walks are carried out to observe the farm behavior, landscape, practices and to analyze the actual practices in the natural settings. This is a useful method which is used in ecological studies to estimate the population of animals (Stern *et al.,* 2004). Collected data are initially entered in computer carefully using Microsoft Excel. Some data are checked randomly against

original completed questionnaires to detect entry errors. Accordingly, the detected errors are corrected for analysis.

Descriptive statistical analysis including frequency distribution, percentage, cross tabulation and mean are used for data analysis to summarize the farmers' economic characteristics and farm specific characteristics.

3.10 Tests of normality

In this experiment, normality test was done for income and costs data by the Kolmogorov–Smirnov test in SPSS Version 22. To get normal distribution, all income and cost data were transformed to natural logarithm (e-base) and tested for normality. The Kolmogorov–Smirnov test (K–S test or KS test) is a nonparametric test of the equality of continuous, one-dimensional probability distributions that can be used to compare our sample with a reference probability distribution.

3.11 Log transformation of data

The log transformation was used to make highly skewed distributions less skewed. This was valuable both for making patterns in the data more interpretable and for helping to meet the assumptions of inferential statistics. In this experiment, costs and income data of homestead, cropland and orchard data were transformed to natural logarithm (e-base) and tested for normality. After analysis of log transformed data, antilogarithmic data were presented in all cases.

3.12 Regression equation:

A regression equation was used in stats to find out what relationship, if any, exists between sets of data. In this research, three years costs and income data were surveyed and the trend of the money flow was found out. That trend (increasing or decreasing a year) was modeled with a regression equation to predict future cash flow.

The linear regression equation is, Y= a + bX

$$\text{Here,b} = \frac{N\sum XY-(\sum X)(\sum Y)}{N\sum X^2-(\sum X)2}, a = \frac{\sum Y-b\sum X}{N}$$

X=Independent variable (Here, Production period in year)

Y= Dependent variable (Here, total costs and total income per year, BCR etc.)

N= Total number of years (Here, 10 years)

3.13 Coefficient of determination (R^2)

The coefficient of determination (denoted by R^2) is a key output of regression analysis. It is interpreted as the proportion of the variance in the dependent variable that is predictable from the independent variable. R^2 for a linear regression model with one independent variable is:

$$R^2 = \{(1 / N) * \Sigma [(x_i - x) * (y_i - y)] / (\sigma_x * \sigma_y) \}^2$$

where N is the number of observations used to fit the model, Σ is the summation symbol, x_i is the x value for observation i, x is the mean x value, y_i is the y value for observation i, y is the mean y value, σ_x is the standard deviation of x, and σ_y is the standard deviation of y.

- The coefficient of determination is the square of the correlation (r) between predicted y scores and actual y scores; thus, it ranges from 0 to 1.
- With linear regression, the coefficient of determination is also equal to the square of the correlation between x and y scores.
- An R^2 of 0 means that the dependent variable cannot be predicted from the independent variable.
- An R^2 of 1 means the dependent variable can be predicted without error from the independent variable.
- An R^2 between 0 and 1 indicates the extent to which the dependent variable is predictable. An R^2 of 0.10 means that 10 percent of the variance in *Y* is predictable from *X*; an R^2 of 0.20 means that 20 percent is predictable; and so on.

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

This results and discussion chapter describes the analysis and discussion of costs and incomes of homestead, cropland and orchard agroforestry systems grown by the farmers of Kaharole Upazila under Dinajpur district. The study considered some selected characteristics of the farmers like farm size, age of trees, tree spacing, agroforestry growers sex, level of education, family size, etc. and explored relationship with homestead, cropland, orchard agroforestry. These are described in the following sections:

4.1 Respondent age

Respondent age were categorized in two groups. They were age (15-35) group age (36-64) group.

Table 4.1. Showed age category of agroforestry growers of Kaharole Upazila of Dinajpur district. There were 20 respondents in each category of agroforestry systems. In homestead agroforestry same 50% was recorded in age group (15-35) and age group (36-64). In cropland agroforestry maximum 75% was recorded in age group (36-64) and minimum number 25% was recorded in age group (15-35) category. In orchard agroforestry maximum number 85% was recorded in age group (36-64) category and the minimum number 15% was recorded in age group (15-35). Total number of agroforestry systems were recorded maximum 70% in age group (36-63) and minimum 30% in age group (15-35) category.

Table 4.1. Age category of agroforestry growers of Kaharole upazila of Dinajpur districts

Agroforestry systems	Respondent age				Total
	No. of respondent Age group (15-35)	Percentage of respondent age	No. of respondent Age group (36-64)	Percentage of respondent age	
Homestead agroforestry	10	50%	10	50%	20
Cropland agroforestry	5	25%	15	75%	20
Orchard agroforestry	3	15%	17	85%	20
Total	18	30%	42	70%	60

4.2 Family size

Family size of agroforestry growers was categorized in four groups. They were lower, medium and higher and large size.

Table 4.2. shows the family size category of respondents of Kaharole Upazila of Dinajpur district. There were 20 respondents in each category of agroforestry systems. In homestead agroforestry maximum 55% was recorded in medium size, followed by higher size category 40%, and minimum 5% in large size. In cropland agroforestry maximum 45% was recorded in medium size category followed by higher 35%, minimum 10% in both lower and large size. In orchard agroforestry maximum 60% was recorded in medium size followed by large 25% and minimum 15% in higher size. Total number of agroforestry systems was recorded maximum 53% in medium size followed by higher size 30% large size 14% and minimum 3% in lower size.

Table 4.2. Family size category of agroforestry growers of Kaharole upazila of Dinajpur districts

Agroforestry systems	Family size Category								Total
	Lower size (1-3)	Percentage	Medium size (4-5)	Percentage	Higher size (6-7)	Percentage	Large (>8)	Percentage	
Homestead agroforestry	0	0%	11	55%	8	40%	1	5%	20
Cropland agroforestry	2	10%	9	45%	7	35%	2	10%	20
Orchard agroforestry	0	0%	12	60%	3	15%	5	25%	20
Total	2	3%	32	53%	18	30%	8	14%	60

4.3 Level of education

Level of education was categorized in four groups. They were primary, secondary and higher secondary and tertiary.

Table 4.3. shows level of education (0 to upward) category of respondents of Kaharole Upazila of Dinajpur district. There were 20 respondents in each category of agroforestry systems. In homestead agroforestry maximum 55% was recorded in secondary category, followed by primary 30% and minimum number 15% in tertiary category. In cropland agroforestry maximum 40% was recorded in secondary category followed by higher secondary 30%, primary 20% and minimum number 10% in tertiary category. In orchard agroforestry maximum 45% was recorded in higher secondary category followed by secondary 30% primary 20% and minimum number 5% in tertiary category. Total number of agroforestry systems were recorded in secondary 42% higher secondary 30%, primary 23% and tertiary 5%.

Table 4.3. Level of education (0 to upward) category of agroforestry growers of Kaharole upazila of Dinajpur districts

Agroforestry systems	Level of education(0 to upward)								Total
	Primary	Percentage	Secondary	Percentage	Higher secondary	Percentage	Tertiary	Percentage	
Homestead agroforestry	6	30%	11	55%	3	15%	0	0%	20
Cropland agroforestry	4	20%	8	40%	6	30%	2	10%	20
Orchard agroforestry	4	20%	6	30%	9	45%	1	5%	20
Total	14	23%	25	42%	18	30%	3	5%	60

4.4 Respondent Sex

Respondent sex were categorized in two groups. They were male and female.

Table 4.4. shows sex category of agroforestry growers of Kaharole Upazila of Dinajpur district. There were 20 respondents in each category of agroforestry systems. In homestead agroforestry maximum 80% was recorded in female and minimum 20% was male. In cropland agroforestry maximum number 85% was recorded in male and minimum 15% in female. In orchard agroforestry maximum 95% was recorded in male and the minimum 5% in female. Total number of agroforestry practices was recorded maximum 67% in male and minimum in female 33%.

Table 4.4. Sex category of agroforestry growers of Kaharole upazila of Dinajpur districts

Agroforestry systems	Respondent sex				Total
	Male	Percentage	Female	Percentage	
Homestead agroforestry	4	20%	16	80%	20
Cropland agroforestry	17	85%	3	15%	20
Orchard agroforestry	19	95%	1	5%	20
Total	40	67%	20	33%	60

4.5 Farm Size

We observed four types of farm in Kaharole upazila. They were Lower (≤0.06ha), Medium (0.061-0.100), Higher size (0.101-0.160) and Large (≥0.161) .Here farm size was expressed in hectare.

Table 4.5: shows farm size category of agroforestry growers of Kaharole Upazila of Dinajpur district. There were 20 respondents in each category of agroforestry systems. In homestead agroforestry maximum 65% was recorded in medium (0.061-0.100) category, and minimum 35% was recorded in low (≤0.06) category. In cropland agroforestry maximum 35% was recorded in both high and large category followed by medium 20% and minimum 10% was recorded in low category. In orchard agroforestry maximum 35% was recorded in large category followed by high 30% and medium 20% category, and minimum 15% was recorded in low category. Total number of agroforestry practices were recorded in medium size 35% large size 23% high size 22% and low size 20%.

Table 4.5: Farm size category of agroforestry growers of Kaharole Upazila of Dinajpur district

Agroforestry systems	Farm size in ha								Total
	Lower size (≤0.06 ha)	Percentage	Medium size (0.061-0.10 ha)	Percentage	Higher size (0.101-0.16 ha)	Percentage	Large (≥0.161 ha)	percentage	
Homestead agroforestry	7	35%	13	65%	0	0%	0	0%	20
Cropland agroforestry	2	10%	4	20%	7	35%	7	35%	20
Orchard agroforestry	3	15%	4	20%	6	30%	7	35%	20
Total	12	20%	21	35%	13	22%	14	23%	60

4.6 Tree age category

Tree age of agroforestry practices were categorized in four groups which were age (1-2), age (3-5), age (6-10) and age (10+).

Table 4.6: shows tree age category of Kaharole Upazila of Dinajpur district. There were 20 practices in each category of agroforestry systems. In homestead agroforestry maximum 65% was recorded in medium age (6-10) category, and minimum 35% was recorded in high age (10+) category. In cropland agroforestry maximum 75% was recorded in low age (3-5) category followed by very low age (1-2) and medium age (6-10), minimum 5% was recorded in high age category (10+). In orchard agroforestry maximum 45% was recorded in high age (10+) category followed by low age (3-5), and minimum 25% was recorded in medium age (6-10) category. Total number of agroforestry systems were recorded in low age 35%, medium age 33%, high age 29%, and 3% very low age.

Table 4.6: Tree age category of agroforestry practices of Kaharole Upazila of Dinajpur district

Agroforestry systems	Tree age category								Total
	Very low age (1-2)	Percentage	Low age (3-5)	Percentage	Medium age(6-10)	Percentage	High age (10+)	Percentage	
Homestead agroforestry	0	0%	0	0%	13	65%	7	35%	20
Cropland agroforestry	2	10%	15	75%	2	10%	1	5%	20
Orchard agroforestry	0	0%	6	30%	5	25%	9	45%	20
Total	2	3%	21	35%	20	33%	17	29%	60

4.7 Plant to plant spacing

Plant to plant spacing were categorized in four groups which were irregular spacing, low(1-7), medium(8-13), large(13+).

Table 4.7: shows plant to plant spacing of agroforestry systems of Kaharole Upazila of Dinajpur district. There were 20 practices in each category of agroforestry systems. In homestead agroforestry irregular spacing was recorded in 100% practices. In cropland agroforestry maximum 80% was recorded in PP space (8-13) category, and minimum 10% was recorded both in PP space (14- upward) and irregular spacing category. In orchard agroforestry maximum 45% was recorded in PP space (14-upward) category followed PP space (8-13), irregular spacing and lowest 10% was recorded in PP space (1-7) category.

Table 4.7: Plant to plant spacing (ft) of agroforestry systems of Kaharole upazila of Dinajpur district

Agroforestry system	Plant to plant spacing(ft)								Total
	Irregular spacing	Percentage	PP space (1-7)	Percentage	PP space (8-13)	Percentage	PP(14 - upward)	Percentage	
Homestead agroforestry	20	100%	0	0%	0	0%	0	0%	20
Cropland agroforestry	2	10%	0	0%	16	80%	2	10%	20
Orchard agroforestry	3	15%	2	10%	6	30%	9	45%	20
Total	25	42%	2	3%	22	37%	11	18%	60

4.8 Row to row spacing

Row to row spacing were categorized in four groups which were irregular spacing, low (upto 7), medium (8-13), large (14 to upward).

Table 4.8: shows row to row spacing of agroforestry systems of Kaharole Upazila of Dinajpur district. There were 20 practices in each category of agroforestry systems. In homestead agroforestry 100% practices were recorded in irregular spacing. In cropland agroforestry maximum 75% was recorded in RR space (8-13) category followed RR space (14- upward), irregular spacing and minimum 5% was recorded in RR space (upto -7) category. In orchard agroforestry maximum 45% was recorded in RR space (14-upward) category followed RR space (8-13), irregular spacing and minimum 10% was recorded in RR space (upto -7) category.

Table 4.8: Row to row spacing (ft) of agroforestry systems of Kaharole upazila of Dinajpur district

Agroforestry systems	Row to row spacing(ft)								Total
	Irregular spacing	Percentage	RR space (upto 7)	Percentage	RR space (08-13)	Percentage	RR (14-upward)	Percentage	
Homestead agroforestry	20	100 %	0	0%	0	0%	0	0%	20
Cropland agroforestry	2	10%	1	5%	15	75%	2	10%	20
Orchard agroforestry	3	15%	2	10%	6	30%	9	45%	20
Total	25	42%	3	5%	21	35%	11	18%	60

4.9 Production cost analysis of different agroforestry systems

The production cost of the different agroforestry systems is an important indicator of how much grower's expense in their farm systems or practices. Production costs per hectare of three agroforestry systems (viz. homestead, cropland and orchard) and different agroforestry practices (viz. mango, litchi, and etc. based practices) of Kaharole Upazila are presented in Figures 4.1 to 4.4.

4.9.1 Production cost of homestead agroforestry system

Figure 4.1 shows the three years actual production costs and seven years forecasted production costs of homestead agroforestry of Kaharole Upazila under Dinajpur district. First year production cost of homestead agroforestry was recorded Tk. 10854 per hectare. Gradually the production cost decreased over time. Second and third year production costs were Tk. 6706 and Tk. 4448 per hectare respectively. Regression line shows the forecasted production cost upto 10 years. The trend line showed the negative value after eight years which indicates that cost of homestead will be negligible after

eight years. The regression equation of homestead production cost was obtained as y= −1015x +8532. The value of R^2=0.78 indicated that the change of a year changes the cost of homestead to 78 % (Figure 4.1).

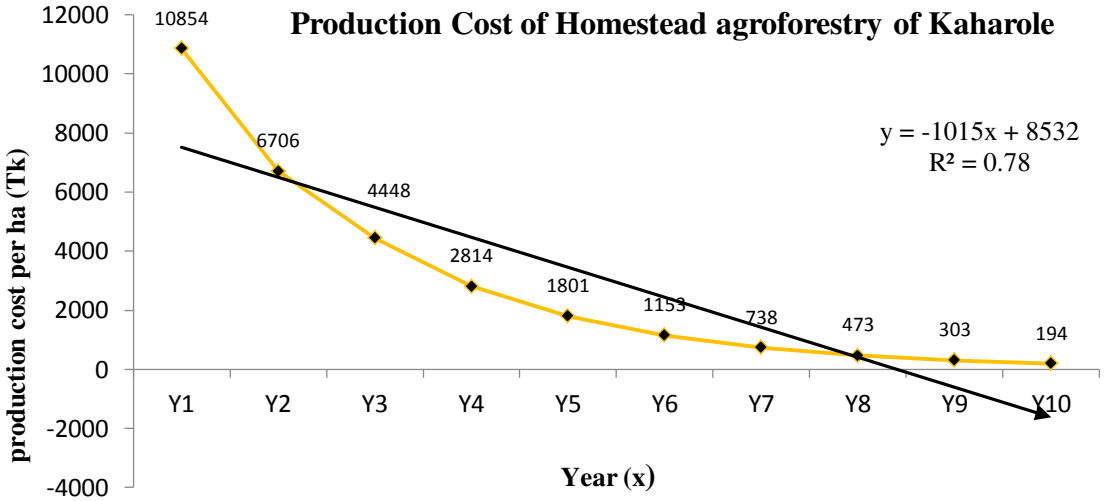

Figure 4.1 Production cost of homestead agroforestry of Kaharole Upazila under Dinajpur district

4.9.2 Production cost of cropland agroforestry system

Figure 4.2 shows the production costs of cropland agroforestry of Kaharole Upazila under Dinajpur district. First year actual production cost of cropland agroforestry was recorded Tk. 90238 per hectare. Gradually the production costs of cropland agroforestry also decreased over time. Second and third year costs were Tk.73130and Tk. 66836 per hectare respectively. Regression line shows the forecasted production costs from fourth year to tenth year. The trend line indicated the cost after 10 years which will be below Tk.20000 per hectare. The regression equation was obtained for cropland agroforestry of Kaharole as y = −7147x + 88632. The equation shows that the initial production cost per hectare of cropland was Tk. 88632. The value of R^2= 0.96 indicates the change of a year (independent variable) changes the cost of cropland agroforestry per hectare (dependent variable) to 96 % (Figure 4.2).

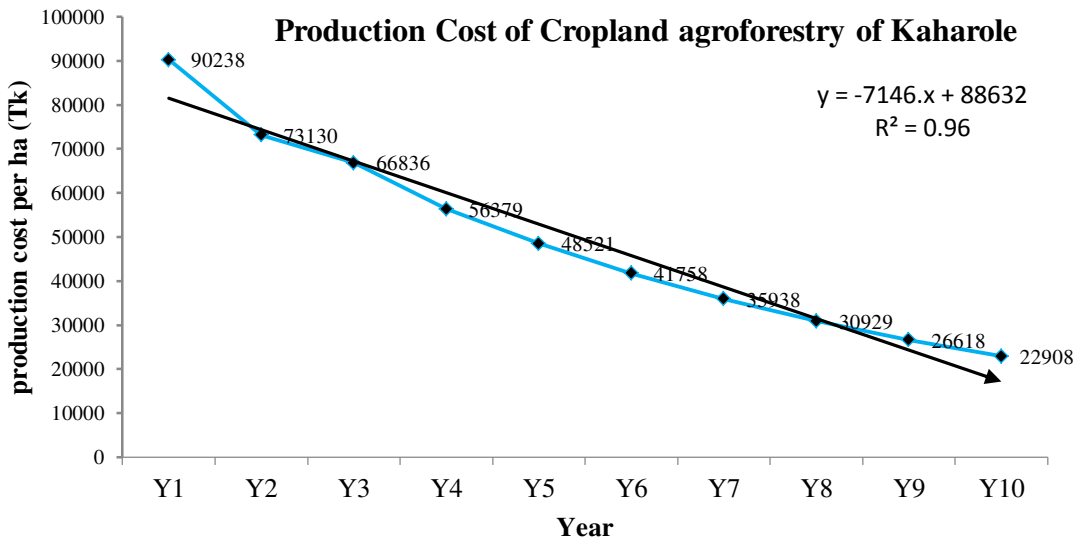

Figure 4.2 production Cost of cropland agroforestry of Kaharole Upazila under Dinajpur district

4.9.3 Production cost of orchard agroforestry system

Figure 4.3 presents the production cost of orchard agroforestry of Kaharole Upazila under Dinajpur district. First year production cost of orchard agroforestry was recorded Tk. 98987 per hectare. Gradually the production cost also decreased over time as homestead and cropland agroforestry. Second and third year production cost were Tk 59271 and Tk 49126 per hectare. Regression line shows the forecasted production cost upto 10 years. The trend line indicates that the production cost of orchard will be negligible after nine years. The regression equation for orchard agroforestry is obtained as y = −9127x +81074, which shows the initial cost of orchard establishment is Tk. 81074 per hectare. The value of the coefficient of determination (R^2) is 0.83 which indicates that for a year (independent variable) change the cost of orchard changes to 83%.

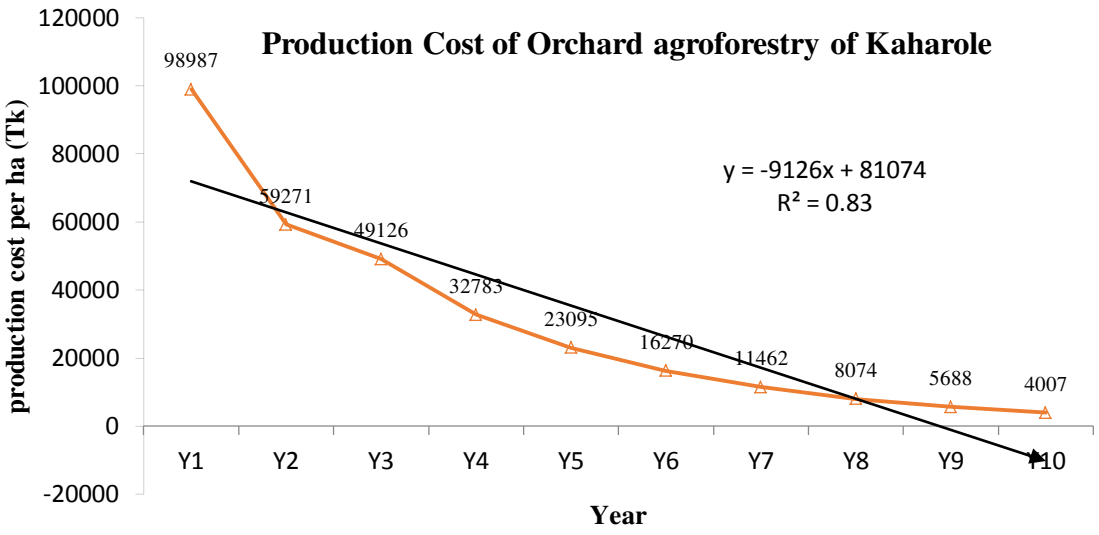

Figure 4.3 Production costs of orchard agroforestry system of Kaharole Upazila

4.9.4 Production costs of different agroforestry practices

Figure 4.4 presents three years production cost of different agroforestry practices of Kaharole Upazila. In the first year, highest production cost was recorded in guava based orchard agroforestry practice followed by jujube based cropland, mango+litchi based orchard, mango based cropland, mahogany based cropland, eucalyptus+mahogany based cropland, eucalyptus based cropland, litchi based orchard and the lowest cost was found in mixed home garden practices. Same trend of production cost was recorded in the second and third years for all the practices. Data are log transformed; actual data are presented in appendix 2b

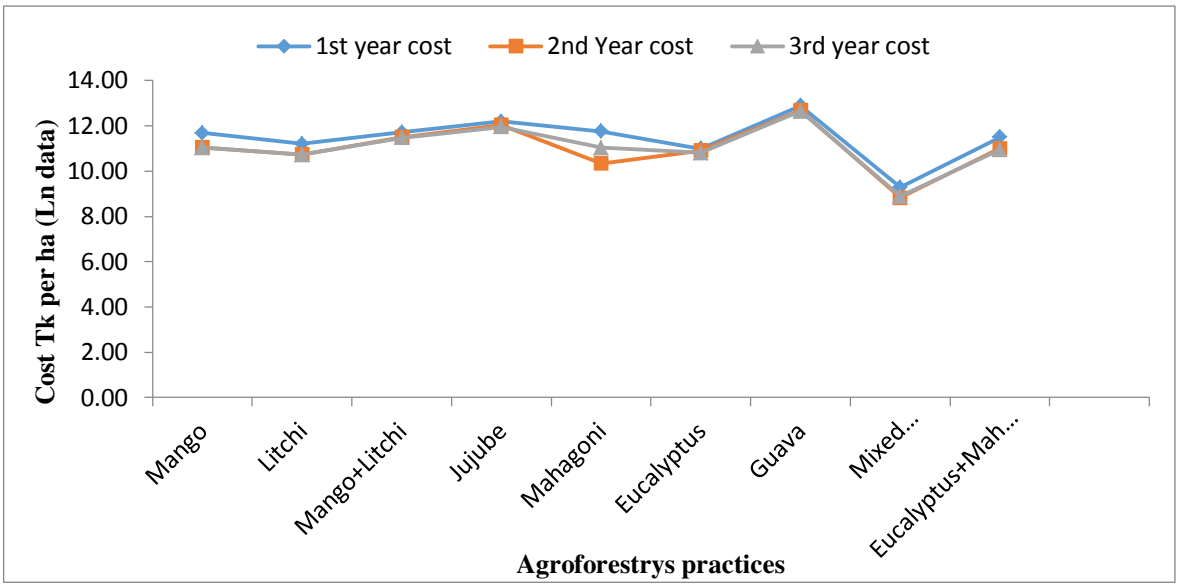

Figure 4.4 Production costs of different agroforestry practices of Kaharole Upazila

4.9.5 Discussion on production costs of different agroforestry systems

In homestead agroforestry initial production cost was higher because it was needed to buy some materials primarily. The cost included seedlings cost, fencing cost, fertilizer, pesticide cost etc.

In cropland agroforestry systems first year cost was TK. 90238 per ha that was more than final periods, there were many reasons for this. The costs includes the seedlings cost, land preparation cost, labour cost, fencing cost, huge amount of inorganic and organic fertilizer costs, irrigation costs, insecticide cost, pesticide costs etc. On the other hand in second year cost was decreased because in second year there was less land preparation cost, less fencing cost, less labour requirement and fertilizer, insecticide cost was also less. But in third year cost was increased some additional costs was added; fence were broken so it was needed to repair the fence. But it was more than homestead cost because in homestead there was no labour cost that means family members were invested their labour.

In orchard agroforestry systems first year cost was TK. 98987 per ha that was more than in compare with second year TK. 59271 per ha. In first year there were seedling costs, land preparation cost, fencing cost, labour cost, fertilizer cost, pesticide cost etc. In second year cost was reduced some additional cost were no needed in the year.

In all discussion of cost we can see that orchard cost were more in compare with homestead and cropland agroforestry because in orchard more intensive care are needed.

The result is in agreement with the result of (Cusworth and Franks 1993; Thapa and Weber 1994) who studied the production cost of different agroforestry practices of pineapple, lemon and banana.

4.10 Gross income analysis of different agroforestry practices

The gross income of the agroforestry grower is an important indicator of how much they acquire from their farm systems and practices. Three years' actual gross income and seven years' forecasted gross incomes of different agroforestry systems and practices of Kaharole Upazila are presented in Figures 4.5 to 4.8.

4.10.1 Gross income of homestead agroforestry

Figure 4.5 shows the gross income of homestead agroforestry of Kaharole Upazila under Dinajpur district. First year gross income of homestead agroforestry was recorded Tk. 52027 per hectare. Gradually the income increased over time. Similarly second year income and third year gross income were recorded as Tk. 63223 and Tk. 76068 per hectare. Regression line shows the forecasted gross income upto 10 years. The trend line indicates the highest income of homestead agroforestry after tenth year (Tk.234234/ha). The regression equation of homestead income is obtained as Y= 22222x +12960, which shows the positive trend of gross income in successive years. The regression equation shows the initial gross income of a homestead before completing a year is Tk. 12960 per hectare (Figure 4.5). The value of the coefficient of determination (R^2) is obtained as 0.958 that means for every year change, there might be a change of income of 95.8 %.

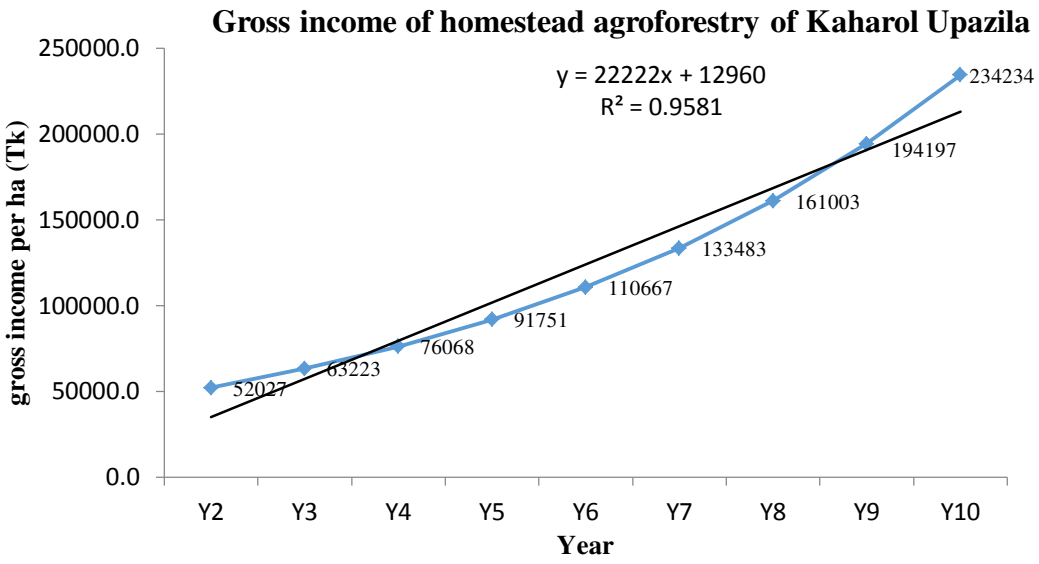

Figure 4.5: Gross Income of homestead agroforestry system of Kaharole Upazila

4.10.2 Gross income of cropland agroforestry

Figure 4.6 shows the gross income of cropland agroforestry of Kaharole Upazila under Dinajpur district. First year gross income of cropland agroforestry was recorded Tk. 138987 per hectare. Gradually the gross income increased over time. Second year income and third year gross income were recorded Tk.157877 and Tk. 157877 per hectare. Regression line shows the forecasted gross income upto 10 years. The trend line indicated the highest gross income of homestead agroforestry after tenth year (Tk.251914/ha). The regression equation was obtained as y= 12157x+125454 which shows the positive trend of gross income in successive years. The regression equation shows the initial gross income of a cropland before completing a year is Tk. 12545 per hectare (Figure 4.6). The value of the coefficient of determination (R^2) is obtained as 0.99 that means for every year change, there might be a change of income of 99 %.

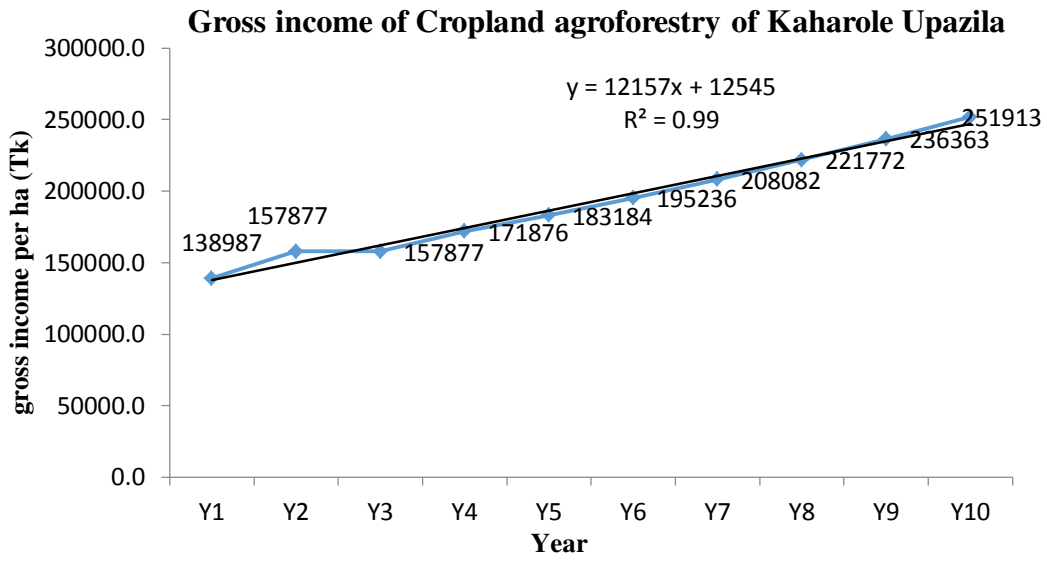

Figure 4.6 Gross income of cropland agroforestry system of Kaharole Upazila

4.10.3 Gross income of orchard agroforestry

Figure 4.7 shows the gross income of orchard agroforestry of Kaharole Upazila. First year gross income of orchard agroforestry was recorded (tk. 317888.47/ha). Second year gross income (tk. 223225 /ha) was decreased than first year but gross income started to increase from third year to subsequent years. Regression line shows the forecasted gross income upto 10 years. The trend line indicated the highest gross income of orchard agroforestry after tenth year (tk.564758/ha). The regression equation of orchard agroforestry system was derived by the trend line is y = 31312x+234245.

The regression equation shows the initial gross income of an orchard before completing a year is Tk. 234245 per hectare (Figure 4.7). The value of the coefficient of determination (R^2) is obtained as 0.8805 that means for every year change, there might be a change of income of 88 %.

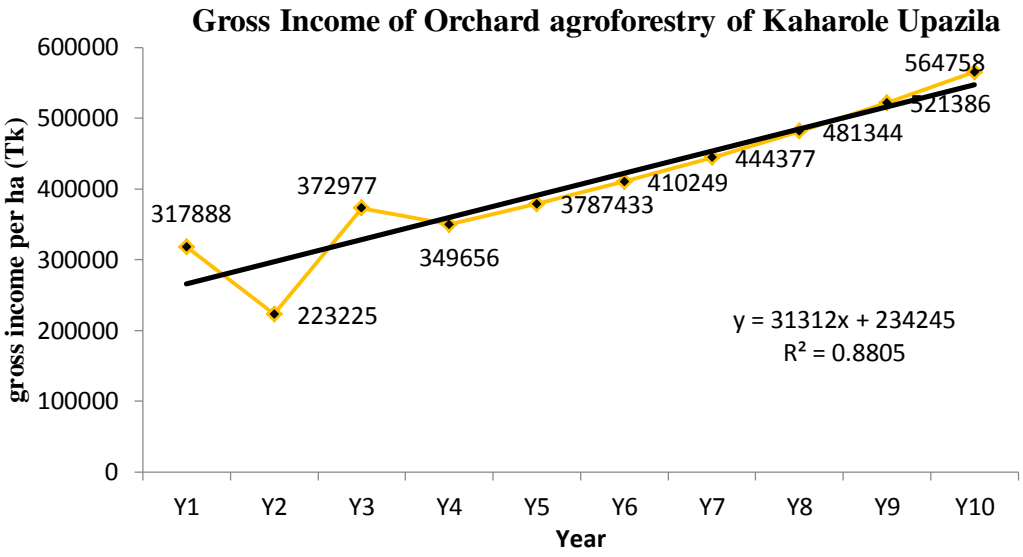

Figure 4.7 Gross income of orchard agroforestry system of Kaharole Upazila

4.10.4 Gross income of different agroforestry practices

Figure 4.8 presents three years gross income of different agroforestry practices of Kaharole Upazila. In the first year, highest gross income was recorded in guava based orchard agroforestry practice followed by eucalyptus + mahogany based cropland, mango based orchard, eucalyptus mahogany based cropland, mango + litchi based orchard, litchi based orchard, mixed home garden and the lowest gross income was found in jujube based agroforestry practices. Same trend of cost was recorded in the second and third years for all the practices. Data are log transformed, detailed analysis is presented in appendix 3.

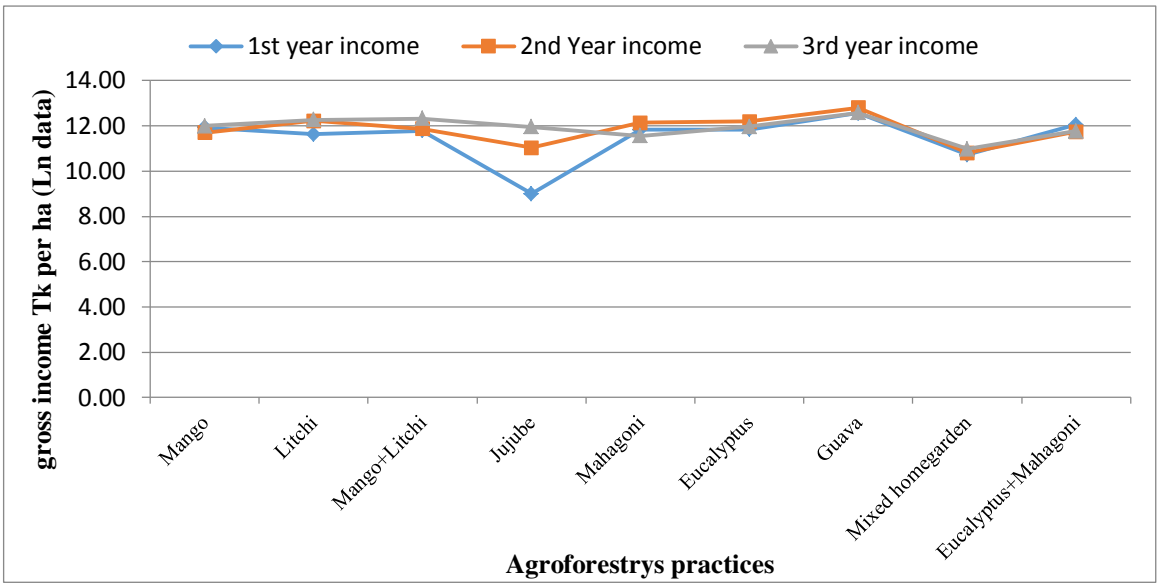

Figure 4.8: Income of different agroforestry practices of Kaharole Upazila

4.10.5 Discussion on gross incomes of agroforestry systems:

In homestead agroforestry first year income 52027 was less than second 63223 and third year's income (76068). First year income was less because seedlings were small and few products were produced. But second third year income was more than first year income because in second and third year yield of vegetables and fruit productions were increased.

In cropland first year income was TK.138987 per ha was more than second year TK. 157877 per ha. In first year crop production was more but fruit and timber production was less than second year so income was decreased in first year. Second and third year income was increased because crop yield was reduced but fruit yield increased in second and third year.

In orchard agroforestry first year income was TK. 317888 per ha and second year income TK. 223225 per ha and third year income TK .372977 per ha. In first year at initial stage crop yield were increased but there were no fruit production because fruit trees and their canopy were small. In second year income was decreased because crop yield were decreased but there were no fruit production. On the other hand third year income was more than second year because crop yield was decreased but fruit trees were started fruiting and income increased.

Our result is in agreement with the result of Hasanuzzaman *et al.* (2014) and Hossain et, al (2005) who studied Diversity and Preference of Agricultural Crops in the Cropland Agro forests of Southwestern Bangladesh and Financial Variability of Shifting Cultivation versus Agroforestry Project.

4.11 Net income analysis

The net income of the homestead agroforestry system is an important indicator by which one can identify how much profit may be obtained from the agroforestry systems or practices. Net income of homestead, cropland and orchard agroforestry systems and different agroforestry practices of Kaharole Upazila are presented in Figures 4.9 to 4.12

4.11.1 Net income of homestead agroforestry

Figure 4.9 shows the gross income of homestead agroforestry of Kaharole Upazila under Dinajpur district. First year net income of homestead agroforestry was recorded Tk32603 per hectare. Similarly, second year net income and third net income were recorded as Tk. 45321 and 58775 per hectare. The trend of net income was increased in subsequent years. Regression line shows the forecasted net income from 4th to 10th year. The trend line indicated the highest net income of homestead agroforestry after 10 years Tk. 150253 per hectare. The regression equation of net income of homestead agroforestry was obtained as y=13086x +19394 which shows the positive trend of net income in successive years. The regression equation shows the initial net income of a homestead before completing a year is Tk.19394 per hectare (Figure 4.9). The value of the coefficient of determination (R^2) is obtained as 1 that means for every year change, there might be a change of income of 1 %.

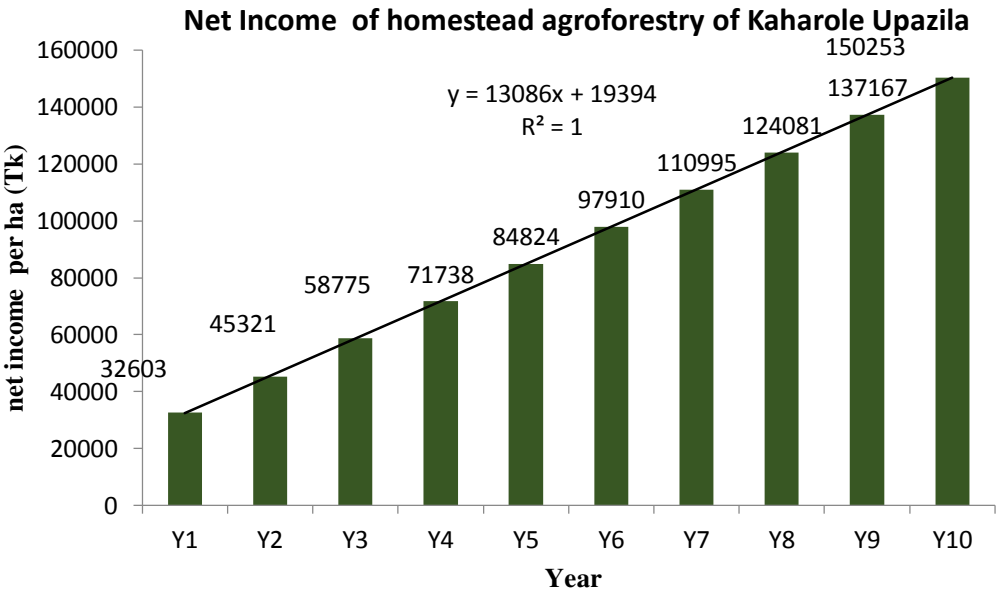

Figure 4.9 Net income of homestead agroforestry of Kaharole Upazila

4.11.2 Net income of cropland agroforestry

Figure 4.9 shows the gross income of cropland agroforestry of Kaharole Upazila under Dinajpur district. First year net income of cropland agroforestry was recorded Tk.48749 per hectare. Similarly, second year net income and third net income were recorded as Tk. 84747 and 91041 per hectare. The trend of net income was increased in subsequent years. Regression line shows the forecasted net income from 4th to 10th year. The trend line indicated the highest net income of cropland agroforestry after 10 years Tk. 244015 per hectare. The regression equation of net income of cropland agroforestry was obtained as y=21146x+32553 which shows the positive trend of net income in successive years. The regression equation shows the initial net income of a cropland before completing a year is Tk.32553 per hectare (Figure 4.10). The value of the coefficient of determination (R^2) is obtained as 0.996 that means for every year change, there might be a change of income of 99.6 %.

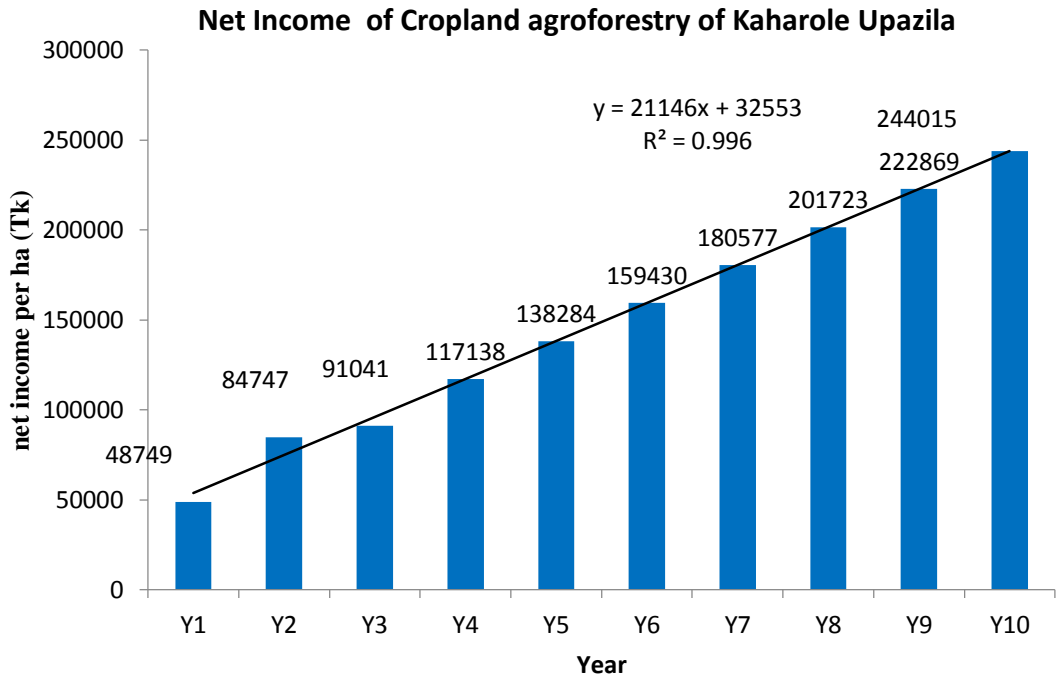

Figure 4.10 Net income of cropland agroforestry of Kaharole Upazila

4.11.3 Net income of orchard agroforestry

Figure 4.11 shows the net income of orchard agroforestry of Kaharole Upazila under Dinajpur district. First year net income of orchard agroforestry was recorded Tk.218902 per hectare. Second year net income was decreased than first year net income and third net income was increased than second year net income. Here second and third year net income were recorded as Tk. 163954 and 323851 per hectare. The trend of net income was increased in subsequent years. Regression line shows the forecasted net income from 4th to 10th year. The trend line indicated the highest net income of orchard agroforestry after 10 years Tk. 655366 per hectare. The regression equation of net income of orchard agroforestry was obtained as y=52475x+130620 which shows the positive trend of net income in successive years. The regression equation shows the initial net income of an orchard before completing a year is Tk. 130620 per hectare (Figure 4.11). The value of the coefficient of determination (R^2) is obtained as 0.9672 that means for every year change, there might be a change of net income of 96.72%.

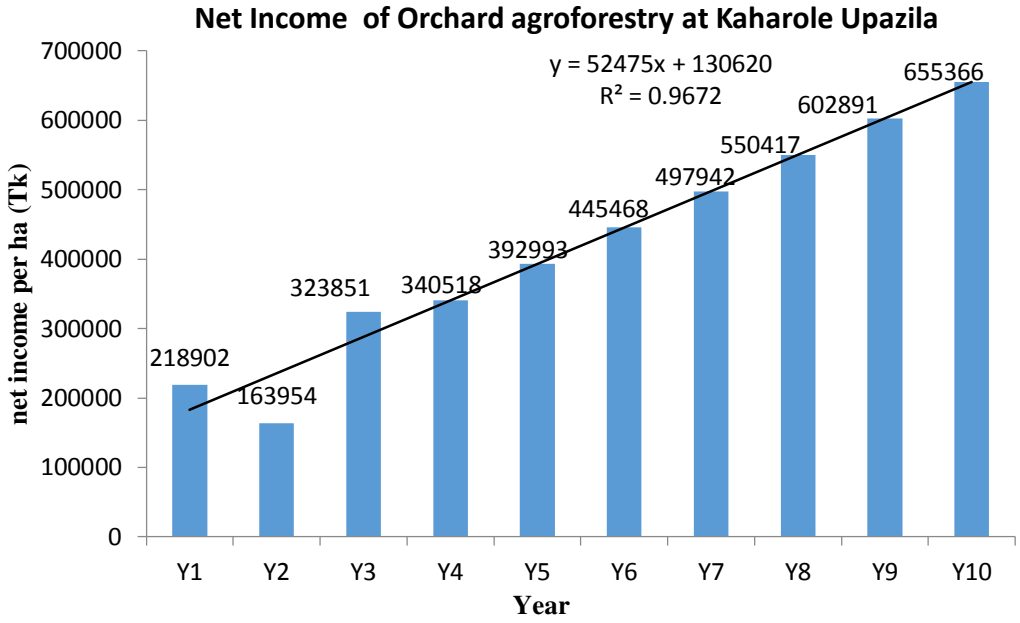

Figure 4.11 Net income of orchard agroforestry of Kaharole Upazila

4.11.4 Net income of different agroforestry practices

Figure 4.12 presents three years net income of different agroforestry practices of Kaharole Upazila. In the first year, highest net income was recorded in eucalyptus based cropland agroforestry practice followed by mixed based guava, mango based orchard, eucalyptus + mahogany based cropland, mahogany based cropland, mango + litchi based orchard, litchi based orchard, mixed based homegarden and the lowest net income was found in jujube based orchard practices. In second year, highest net income was recorded in mahogany based cropland agroforestry and lowest net income was recorded in jujube based orchard agroforestry practices. In third year, highest net income was recorded in mango based and guava based agroforestry practices and lowest net income was recorded in jujube based agroforestry practices.

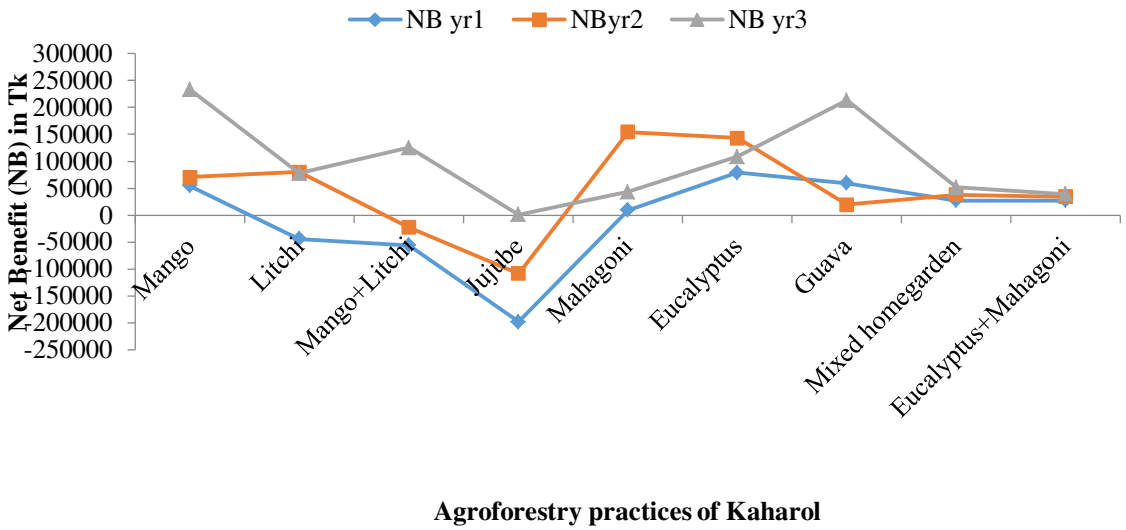

Figure 4.12: Net Income of different agroforestry practices of Kaharole Upazila.

4.12 Benefit cost ratio analysis

A benefit cost ratio (BCR) attempts to identify the relationship between the production cost and benefits of a different agroforestry systems. Benefit cost ratio of agroforestry system or practice is the ratio between gross income and production cost of the respective system or practice. It is unit less because it is a ratio of two same units. In this research, attempt was undertaken to find out the BCR of homestead, cropland and orchard agroforestry systems and different agroforestry practices of Kaharole Upazila by using the natural log (Ln) transformed data.

4.12.1 Benefit cost ratio of homestead agroforestry

Figure 4.12 shows the benefit cost ratio of homestead agroforestry of Kaharole Upazila under Dinajpur district. First year benefit cost ratio of homestead agroforestry was recorded 3.16 per hectare. Gradually the benefit cost ratio increased over time. Similarly second year and third year benefit cost ratio were recorded as 3.43 and 3.73 per hectare. Regression line shows the forecasted benefit cost ratio upto 10 years. The trend line indicates the highest benefit cost ratio of homestead agroforestry after 10 years 6.68.The regression equation of homestead benefit cost ratio is obtained as Y=0.3892x+ 2.5839, which shows the positive trend of benefit cost ratio in successive years. The regression equation shows the initial benefit cost ratio of a homestead before completing a year is

2.5839 per hectare (Figure 4.12). The value of the coefficient of determination (R^2) is obtained as 0.9891 that means for every year change, there might be a change of benefit cost ratio of 98.8 %.

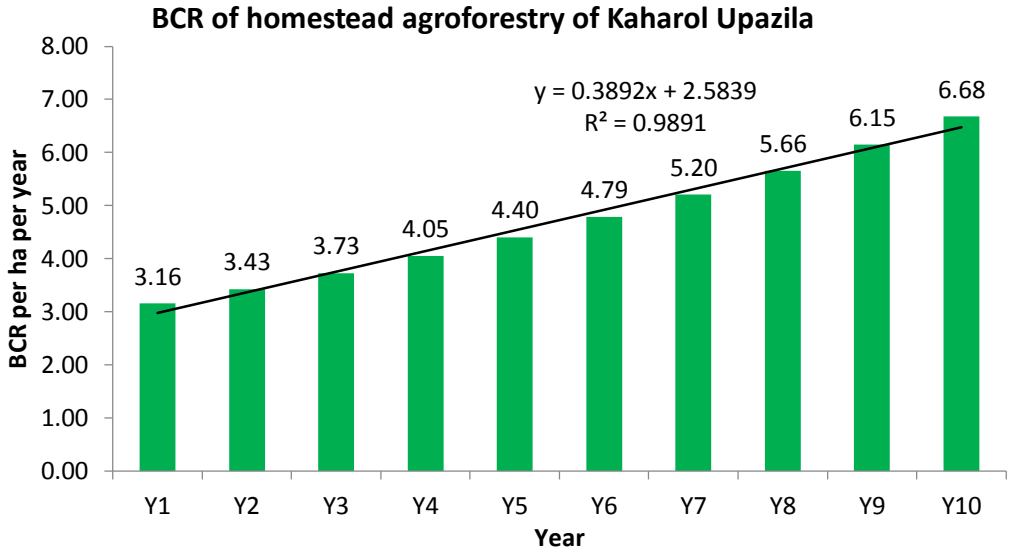

Figure 4.13 Benefit cost ratio of homestead agroforestry of Kaharole Upazila

4.12.2 Benefit cost ratio of cropland agroforestry

Figure 4.12 shows the benefit cost ratio of cropland agroforestry of Kaharole Upazila under Dinajpur district. First year benefit cost ratio of cropland agroforestry was recorded 2.85 per hectare. Gradually the benefit cost ratio increased over time. Similarly second year and third year benefit cost ratio were recorded as 2.99 and 3.27 per hectare. Regression line shows the forecasted benefit cost ratio upto 10 years. The trend line indicates the highest benefit cost ratio of cropland agroforestry after 10 years 5.23.The regression equation of cropland benefit cost ratio is obtained as Y=0.265x+2.4657, which shows the positive trend of benefit cost ratio in successive years. The regression equation shows the initial benefit cost ratio of a cropland before completing a year is 2.4657 per hectare (Figure 4.13). The value of the coefficient of determination (R^2) is obtained as 0.9921 that means for every year change, there might be a change of benefit cost ratio of 99.21 %.

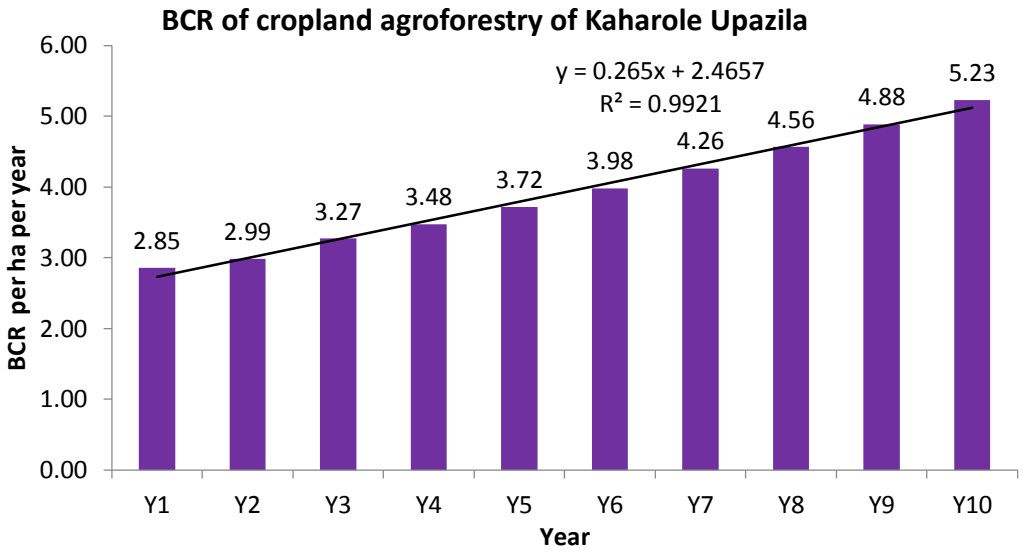

Figure 4.14 Benefit cost ratio of cropland agroforestry of Kaharole Upazila

4.12.3 Benefit cost ratio of orchard agroforestry

Figure 4.14 shows the benefit cost ratio of orchard agroforestry of Kaharole Upazila under Dinajpur district. First year benefit cost ratio of orchard agroforestry was recorded 3.01 per hectare. Benefit cost ratio was increased in second year but decreased in third year. Second year and third year benefit cost ratio were recorded as 3.01 and 3.07 per hectare. Regression line shows the forecasted benefit cost ratio upto 10 years. The trend line indicates the highest benefit cost ratio of orchard agroforestry after 10 years 3.12 per hectare.The regression equation of orchard benefit cost ratio is obtained as Y=0.0102x+3.0142, which shows the positive trend of benefit cost ratio in successive years. The regression equation shows the initial benefit cost ratio of an orchard before completing a year is3.0142 per hectare (Figure 4.14). The value of the coefficient of determination (R^2) is obtained as 0.8458 that means for every year change, there might be a change of benefit cost ratio of 84.58 %.

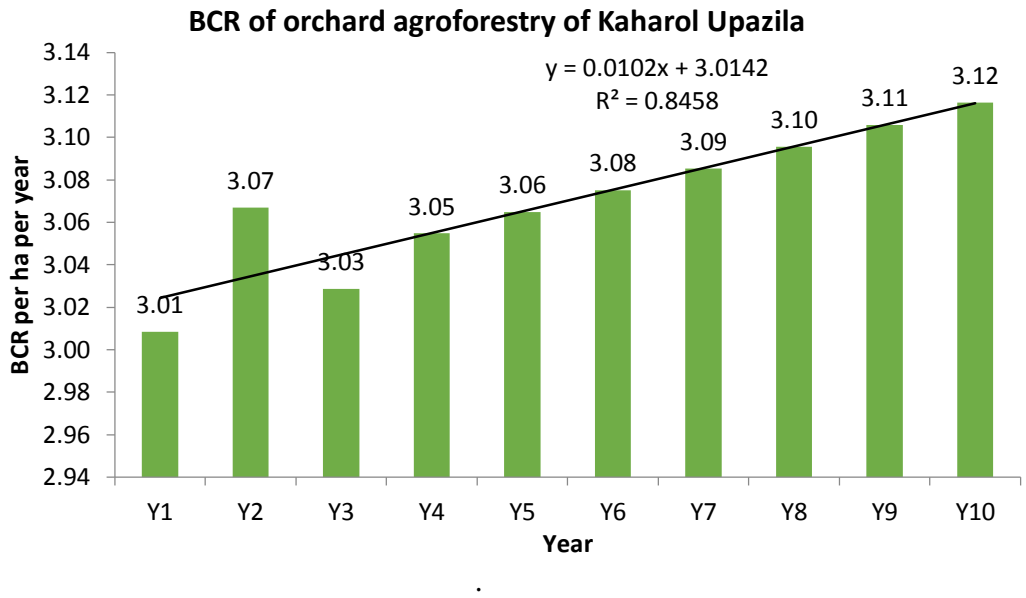

Figure 4.15 Benefit cost ratio of orchard agroforestry of Kaharole Upazila

4.12.4 Benefit cost ratio of different agroforestry practices

Figure 4.16 presents three years benefit cost ratio of different agroforestry practices of Kaharole Upazila. In the first year, highest benefit cost ratio was recorded in mixed home garden based agroforestry practice followed by eucalyptus+magogony based cropland, eucalyptus based cropland, litchi based orchard, guava based orchard, mango based orchard, mango + litchi based orchard, mahogany based cropland and the lowest benefit cost ratio was found in jujube based orchard practices. Same trend of benefit cost ratio was recorded in the second and third years for all the practices.

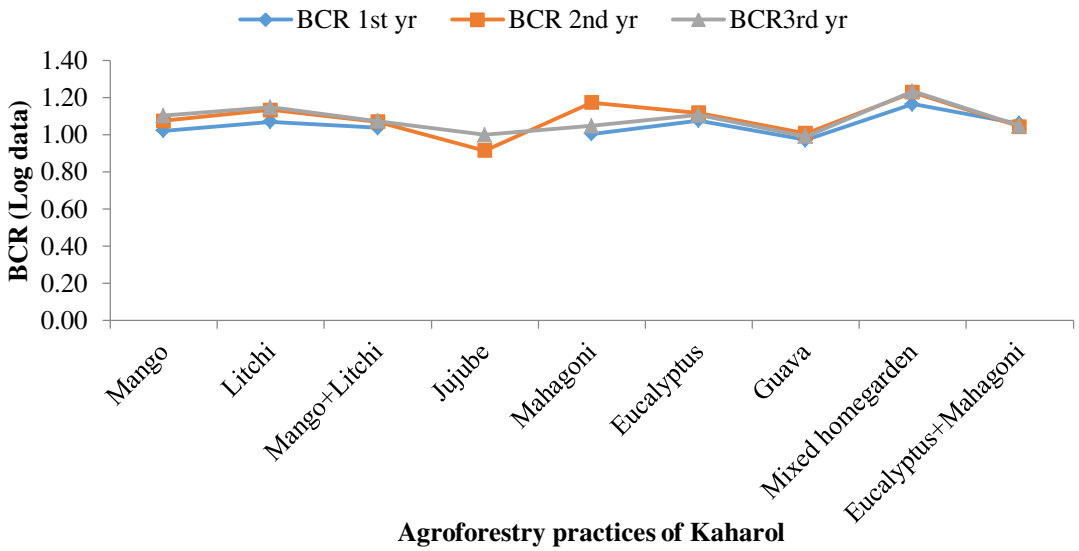

Figure 4.16 Benefit cost ratio of different agroforestry practices of Kaharole Upazila

4.12.5 Discussion on benefit -cost ratio of agroforestry systems

In case of homestead agroforestry systems first year benefit cost ratio was recorded 3.16 and it was increased in successive years. Highest benefit cost ratio was recorded at tenth year 6.68

In case of cropland agroforestry systems first year benefit cost ratio was recorded 2.85 and it was increased in successive years. Highest benefit cost ratio was recorded at tenth year 5.23. Benefit cost ratio was increased because in successive years cost was less than income.

In case of orchard agroforestry systems first year benefit cost ratio was recorded 3.01 and it was increased in successive years. Highest benefit cost ratio was recorded at ten year 3.12. Benefit cost ratio was increased because in successive years cost was less than income.

Our result is in agreement with the result of Kibria and Shaha (2011) who studied the BCR of agroforestry practices with pineapple, lemon and banana in the Modhupur sal forest of Bangladesh.

4.13 Identification of different agroforestry practices

Different types of agroforestry practices were observed in Kaharole Upazila during the field survey of the present study. The following pie chart presents the number of

different agroforestry practices of Kaharole upazila. Nine agroforestry practices were recorded based on the presence of perennial tree species during the study. Mixed homegarden occupied the highest number (21) followed by Litchi (14), Mango (12) based orchard practices and lowest number was recorded in Eucalyptus (1), Jujube (1), Mahagony (1) based cropland practices (Figure 4.17).

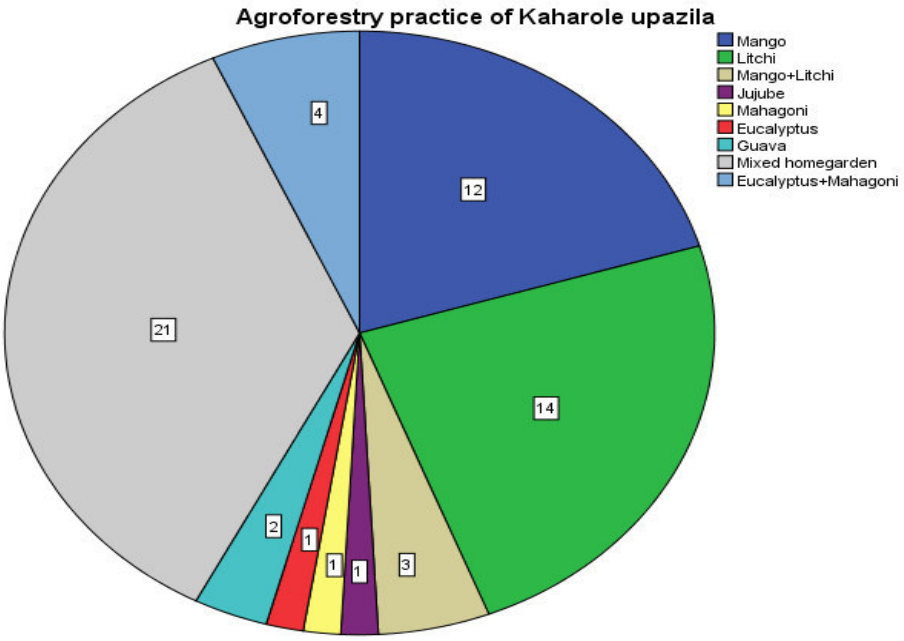

Figure 4.17 Number of different agroforestry practices of Kaharole upazila

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

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5.1 Summary

The study was conducted in four union of Kaharole Upazila in Dinajpur district. Sites were selected purposively as the locale. 60 respondents were selected through preference sampling method. Respondents of the survey were selected based on four different farm categories. Data were collected by using pre-tested interview schedule and preference ranking. Then the collected data were summarized to meet the objectives of the study. Finally, the collected data were coded, compiled and tabular analyzed to fulfill various objectives. Data were collected through personal interview by the researcher herself from the sample respondents during July, 2017 to January 2018. Respondents' opinion regarding impact of agroforestry on economic evaluation viz. cost, income, net income, benefit cost ratio were the dependent variable of the study. Ten selected characteristics of the farmers were taken as independent variables. The characteristics were respondent age, respondent sex, level of education, family size, farm size, plant to plant spacing, row to row spacing, highest tree age, lowest tree age, agroforestry practices composition constituted the dependent variables in this study.

From questionnaire survey it was found that the age of the respondents in the study area ranged from 15 to 64 years. The highest age percentage of respondents was found on as age group (36-64) and the lowest percentage on age group (15-35). The level of education of the farmers in the study area were found Primary, Secondary, Higher secondary, Tertiary. The maximum percentage of respondents was found on Secondary level (25) and minimum percentage of respondents was found on tertiary (3). The highest family size of respondents was found 'medium'(32) and the lowest family size of respondents was found on 'lower' (2) category. The farm size of the respondents was found maximum in medium (21) and minimum in lower (12) size category. Lowest tree age of agroforestry practices was found highest in age group (1-2) and lowest in age group (6-10). Highest tree age of agroforestry practices was found highest in age group (3-5) and lowest in age group (1-2). Plant to plant (ft) spacing of agroforestry practices was found maximum in irregular spacing (25) and minimum in PP spaing (1-7). Row to row (ft) spacing of agroforestry practices was found maximum in irregular spacing (25) and minimum in RR spacing (1-7). Agroforestry practices were found mango, litchi,

mango+litchi, eucalyptus+mahagony, guava, eucalyptus, mahagony, jujube and mixed homegarden based. Highest practice was found in mixed homegarden and lowest practice was found in eucalyptus, jujube and mahagony based agroforestry practices.

The cost of homestead agroforestry varied from tk. 10853.87 to tk. 193.68 per ha. Highest cost of homestead agroforestry was found in first year and lowest cost was found in ten year. The cost of cropland agroforestry varied from tk. 90238 to tk. 22908 per ha. Highest cost of cropland agroforestry was found in first year and lowest cost was found in ten year. The cost of orchard agroforestry varied from tk. 98987 to tk. 4007 per ha. Highest cost of orchard agroforestry was found in first year and lowest cost was found in ten year. The income of homestead agroforestry varied from tk. 52027 to tk. 234233.6 per ha. Highest income of homestead agroforestry was found in ten year and lowest income was found in first year. The income of cropland agroforestry varied from tk. 138987.2 to tk. 251913.9 per ha. Highest income of cropland agroforestry was found in ten year and lowest income was found in first year.The income of orchard agroforestry varied from tk. 317888.47 to tk. 564758.49 per ha. Highest income of orchard agroforestry was found in ten year and lowest income was found in first year. The net income of homestead agroforestry varied from tk. 32603 to tk. 150253 per ha. Highest net income of homestead agroforestry was found in ten year and lowest income was found in first year. The net income of cropland agroforestry varied from tk. 48749 to tk. 244015 per ha. Highest net income of cropland agroforestry was found in ten year and lowest income was found in first year. The net income of orchard agroforestry varied from tk. 218902 to tk. 655366 per ha. Highest net income of orchard agroforestry was found in ten year and lowest income was found in first year. The benefit cost ratio of homestead agroforestry varied from 3.16 to 6.68 per ha. Highest benefit cost ratio of homestead agroforestry was found in ten year and lowest income was found in first year. The benefit cost ratio of cropland agroforestry varied from 2.85 to 5.23 per ha. Highest benefit cost ratio of cropland agroforestry was found in ten year and lowest income was found in first year. The benefit cost ratio of orchard agroforestry varied from 3.01to 3.12 per ha. Highest benefit cost ratio of orchard agroforestry was found in ten year and lowest income was found in first year.

5.2 Conclusion

From the findings of this study it can be concluded that the initial production cost of orchard agroforestry system was higher than cropland and homestead agroforestry systems. Lowest production cost was found in homestead agroforestry system. But highest income was found in orchard agroforestry system and lowest income was found in homestead agroforestry system. Again in orchard agroforestry system net income was also highest and in homestead agroforestry system net income was also lowest. However benefit cost ratio was highest in homestead agroforestry system followed by cropland agroforestry system because here cost was less but benefit was more. As orchard agroforestry system provide more net income in spite of its higher initial cost, farmers should give more emphasis to grow orchard agroforestry by minimizing the initial cost.

5.3 Recommendations

The following recommendations are made on the basis of findings of the current study:

i) Among the three agroforestry systems orchard agroforestry may give more net income. So, the farmers of Kaharole upazila may give more emphasis on orchard agroforestry system.

ii) Orchard owner of Kaharole upazila do not follow any standard spacing for tree plantation. So, they should be trained on spacing of tree plantation and species selection.

iii) The orchard agroforestry system can be improved by proper care and management and crops having low economic value should be replaced by high economic value.

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APPENDICES

APPENDICES

Appendix-1: Questionnaire of field survey and measurement

QUESTIONNAIRE

Department of Agroforestry and Environment
Hajee Mohammad Danesh Science & Technology University, Dinajpur

.....

A DATA COLLECTION SHEET FOR THE STUDY ON

"Cost- Benefit Analysis of Different Agroforestry Systems of Kaharole Upazila of Dinajpur District".

Name of the respondent: …… Serial no: ……..

Village: …….. Union: …….

Upazila: ……. District: ……

Mobile No:.....Name of Practice:.....

(Please provide necessary information of the following issues)

1. Age: How old are you? ……. Years.

2. Education: Please mention your level of education.....

3. Family Size: Please indicate the numbers of your family members

Family size	Male	Female

4. **Farm Size:** Please indicate area of your land according to use

Sl. No.	**Use**	**Local Unit**	**Hectare**
1.	Homestead area		
2.	Crop land agroforestry		
3.	Orchard area		
Total land			

5. Trees in Homestead/Cropland/Orchard.

Sample area.....Spacing: Plant to plant:.....Row to Row:.....

6. Yield Production: Please mention the year wise yield and sale price of products

Income item (Return items)	1st Year			2nd Year			3rd Year		
	Amount	Rate	Taka	Amount	Rate	Taka	Amount	Rate	Taka

7. Please mention year wise costs of your practices

Cost items	1st Year			2nd Year			3rd Year		
	Amount	Rate	Taka	Amount	Rate	Taka	Amount	Rate	Taka
Sapling									
Organic fertilizer									
Inorganic Fertilizer									
Land preparation									
Labor									
Land									
Fencing									
Opportunity cost									
Rent									
Irrigation									
Miscellaneous Cost									

8. Can you tell me about the annual income from your homestead/cropland/ orchard agroforestry?

Items	Taka
Timber	
Fuel wood	
Fruits	
Vegetables	
Nurseries	
Livestock/poultry/Duck/Koyel	
Others.....Please specify	

9. Problem faced by respondents in Homestead/Cropland/Orchard based agroforestry practices:

a)……

b)……

c)……

d)……

e)……

f)……

Thank you very much for your cooperation

Signature of the interviewer

Appendix 1a: Descriptive Analysis of log transformed cost

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
1st year cost	Homestead agroforestry	20.00	9.29	0.49	0.11	9.06	9.52	8.51	10.64
	Cropland agroforestry	20.00	11.41	0.53	0.12	11.16	11.66	10.62	12.88
	Orchard agroforestry	20.00	11.50	0.96	0.21	11.05	11.95	9.07	13.33
	Total	60.00	10.74	1.24	0.16	10.42	11.05	8.51	13.33
2nd year cost	Homestead agroforestry	20.00	8.81	0.43	0.10	8.61	9.01	8.10	9.76
	Cropland agroforestry	20.00	10.93	0.46	0.10	10.72	11.15	10.11	12.02
	Orchard agroforestry	20.00	10.99	1.15	0.26	10.45	11.53	8.22	13.05
	Total	60.00	10.25	1.27	0.16	9.92	10.57	8.10	13.05
3rd year cost	Homestead agroforestry	20.00	8.40	0.49	0.11	8.17	8.63	7.72	9.20
	Cropland agroforestry	20.00	10.82	0.49	0.11	10.60	11.05	9.55	11.94
	Orchard agroforestry	20.00	10.80	1.22	0.27	10.23	11.37	7.81	12.99
	Total	60.00	10.01	1.40	0.18	9.65	10.37	7.72	12.99

Appendix 1b: Descriptive Analysis of log transformed income

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
1st year income	Homestead agroforestry	18.00	10.68	0.38	0.09	10.49	10.87	10.11	11.50
	Cropland agroforestry	20.00	11.84	0.56	0.13	11.58	12.10	10.53	13.67
	Orchard agroforestry	11.00	12.67	1.32	0.40	11.78	13.56	11.21	14.94
	Total	49.00	11.60	1.07	0.15	11.29	11.91	10.11	14.94
2nd year income	Homestead agroforestry	18.00	10.86	0.39	0.09	10.67	11.05	10.16	11.72
	Cropland agroforestry	20.00	11.97	0.59	0.13	11.69	12.25	10.81	13.92
	Orchard agroforestry	10.00	12.32	0.79	0.25	11.75	12.88	11.47	13.91
	Total	48.00	11.63	0.83	0.12	11.38	11.87	10.16	13.92
3rd year income	Homestead agroforestry	19.00	11.05	0.46	0.11	10.83	11.28	10.40	12.19
	Cropland agroforestry	20.00	11.97	0.55	0.12	11.87	12.38	11.20	14.03
	Orchard agroforestry	10.00	12.83	0.82	0.26	12.25	13.41	11.64	14.33
	Total	49.00	11.85	0.90	0.13	11.60	12.11	10.40	14.33

Appendix 2a: ANOVA Table for Agroforestry practices of Kaharole

ANOVA Table for Agroforestry practices of Kaharole							
			Sum of Squares	df	Mean Square	F	Sig.
C1 * Agroforestry practice	Between Groups	(Combined)	75.795	8	9.474	30.849	.000
		Linearity	35.216	1	35.216	114.664	.000
		Deviation from Linearity	40.579	7	5.797	18.875	.000
	Within Groups		15.356	50	.307		
	Total		91.151	58			
C2 * Agroforestry practice	Between Groups	(Combined)	75.891	8	9.486	27.262	.000
		Linearity	31.842	1	31.842	91.508	.000
		Deviation from Linearity	44.049	7	6.293	18.084	.000
	Within Groups		17.399	50	.348		
	Total		93.290	58			
C3 * Agroforestry practice	Between Groups	(Combined)	71.209	8	8.901	23.372	.000
		Linearity	29.737	1	29.737	78.082	.000
		Deviation from Linearity	41.472	7	5.925	15.556	.000
	Within Groups		19.042	50	.381		
	Total		90.251	58			

Appendix 2b: Log transformed data and actual data of cost of agroforestry practices of Kaharole

Log transformed data					Actual data (Tk)		
Agroforestry practice		1st year cost	2nd Year cost	3rd year cost	1st year cost	2nd Year cost	3rd year cost
Mango	Mean	11.68	11.05	11.03	118367	63119	61562
	N	12.00	12.00	12.00			
	Std. Deviation	0.71	0.77	0.85	2	2	2
Litchi	Mean	11.20	10.74	10.72	73074	46025	45316
	N	14.00	14.00	14.00			
	Std. Deviation	0.52	0.59	0.55	2	2	2
Mango+Litchi	Mean	11.72	11.50	11.48	122719	98516	96309
	N	3.00	3.00	3.00			
	Std. Deviation	0.66	0.78	0.65	2	2	2
Jujube	Mean	12.20	12.04	11.95	198025	169753	154321
	N	1.00	1.00	1.00			
	Std. Deviation				1	1	1
Mahagoni	Mean	11.75	10.34	11.03	126588	30875	61750
	N	1.00	1.00	1.00	3	3	3
	Std. Deviation				1	1	1
Eucalyptus	Mean	10.99	10.90	10.81	59280	54340	49400
	N	1.00	1.00	1.00			
	Std. Deviation				1	1	1
Guava	Mean	12.88	12.69	12.65	393005	324633	312096
	N	2.00	2.00	2.00			
	Std. Deviation	0.63	0.51	0.59	2	2	2
Mixed homegarden	Mean	9.28	8.83	8.89	10737	6841	7227
	N	21.00	21.00	21.00			
	Std. Deviation	0.48	0.46	0.49	2	2	2
Eucalyptus+Mahagoni	Mean	11.50	11.01	10.95	98406	60564	56887
	N	4.00	4.00	4.00			
	Std. Deviation	0.35	0.49	0.63	1	2	2
Total	Mean	10.74	10.26	10.28	46211	28692	29055
	N	59.00	59.00	59.00			
	Std. Deviation	1.25	1.27	1.25	4	4	3

Appendix 3: Log transformed data of income of agroforestry practices of Kaharole

Log transformed data of income of agf practices of kaharole									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Ist year income	Mango	12.00	11.92	0.70	0.20	11.47	12.36	11.20	13.84
	Litchi	5.00	11.62	0.21	0.09	11.37	11.88	11.37	11.91
	Mango+Litchi	2.00	11.78	0.08	0.06	11.06	12.50	11.72	11.84
	Jujube	1.00	9.00	.	.	.	.	.	.
	Mahagoni	1.00	11.82	.	.	.	.	11.82	11.82
	Eucalyptus	1.00	11.84	.	.	.	.	11.84	11.84
	Guava	2.00	12.56	1.62	1.15	-1.99	27.11	11.41	13.70
	Mixed homegarden	17.00	10.72	0.40	0.10	10.51	10.93	10.11	11.50
	Eucalyptus+Mahagoni	3.00	12.04	0.23	0.13	11.47	12.62	11.91	12.31
	Total	43.00	11.44	0.80	0.12	11.19	11.68	10.11	13.84
2nd year income	Mango	11.00	11.69	0.48	0.14	11.37	12.01	10.81	12.54
	Litchi	6.00	12.22	0.92	0.38	11.25	13.19	11.51	13.92
	Mango+Litchi	2.00	11.86	0.38	0.27	8.47	15.25	11.60	12.13
	Jujube	1.00	11.03	.	.	.	.	11.03	11.03
	Mahagoni	1.00	12.13	.	.	.	.	12.13	12.13
	Eucalyptus	1.00	12.19	.	.	.	.	12.19	12.19
	Guava	2.00	12.79	0.25	0.18	10.50	15.08	12.61	12.97
	Mixed homegarden	18.00	10.80	0.37	0.09	10.62	10.99	10.16	11.72
	Eucalyptus+Mahagoni	3.00	11.74	0.39	0.23	10.77	12.72	11.49	12.19
	Total	45.00	11.47	0.78	0.12	11.24	11.71	10.16	13.92
3rd year income	Mango	11.00	12.00	1.04	0.31	11.30	12.69	10.53	14.73
	Litchi	6.00	12.26	0.84	0.34	11.38	13.14	11.64	13.80
	Mango+Litchi	3.00	12.31	0.42	0.25	11.26	13.37	11.91	12.75
	Jujube	1.00	11.95	.	.	.	.	11.95	11.95
	Mahagoni	1.00	11.56	.	.	.	.	11.56	11.56
	Eucalyptus	1.00	11.97	.	.	.	.	11.97	11.97
	Guava	2.00	12.58	1.78	1.26	-3.43	28.59	11.32	13.84
	Mixed homegarden	19.00	10.98	0.48	0.11	10.75	11.21	10.40	12.19
	Eucalyptus+Mahagoni	3.00	11.76	0.49	0.28	10.55	12.97	11.32	12.28
	Total	47.00	11.64	0.91	0.13	11.37	11.90	10.40	14.73

Plate 1. Homestead agroforestry system of Kaharole Upazila

Plate 2. Data collection using questionnaire by interview of Kaharole Upazila

Plate3.Information collection from the agroforestry growers of Kaharole Upazila

Plate 4. Eucalyptus–Litchi-Paddy cropland agroforestry practices of Kaharole Upazila

Plate 5. Mango- Pointed gourd cropland agroforestry practices of Kaharole Upazila

Plate 6. Fruit collection from orchard agroforestry practices of Kaharole Upazila

Plate 7. Fruit collection for marketing from orchard agroforestry practices of Kaharole Upazila

Plate 8. Mango- Guava orchard agroforestry practices of Kaharole Upazila

Plate 9. Mango- Guava orchard agroforestry practices of Kaharole Upazila

Plate 10.Information collection from the agroforestry growers of Kaharole Upazila

Plate 11. Mango- bottle gourd cropland agroforestry practices of Kaharole Upazila

Plate 12. Information collection from the agroforestry growers of Kaharole Upazila