

Project ID 551

## Competitive Research Grant

# Sub-Project Completion Report on

Identification and economic analysis of existing  
agroforestry practices in the northern region of  
Bangladesh for better agroforestry practices

Project Duration

May 2017 to September 2018

Department of Agroforestry and Environment  
Hajee Mohammad Danesh Science and Technology University  
Dinajpur-5200



Submitted to  
Project Implementation Unit-BARC, NATP 2  
Bangladesh Agricultural Research Council  
Farmgate, Dhaka-1215



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## **Citation**

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## Acronyms

1st	:	First
2nd	:	Second
3rd	:	Third
BCR	:	benefit-cost ratio
ha	:	hectare
LN	:	natural Log
NPV	:	Net present value
$R^2$	:	Coefficient of determination
SPSS	:	Statistical Package for Social Science
Tk	:	Taka
Yr	:	Year

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## Executive Summary

A study was carried out to identify, document and evaluate the economic potential through costs and benefits analysis of three agroforestry systems like homestead, cropland and orchard agroforestry of four upazila of four districts namely Kaharole upazila of Dinajpur district, Jaldhaka upazila of Nilphamari district, Panchbibi upazila of Joypurhat district and Gurudaspur upazila of Natore district of Bangladesh. An extensive field survey and field experiments were conducted during June 2017 to September 2018 at different unions and villages of the studied area. 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 of different agroforestry systems. A total of 240 agroforestry practices including 80 homesteads, 80 orchards and 80 croplands were evaluated for cost and benefit analysis. Initial three years costs and income data were collected from the field survey. A projection of seven years cost and income was also produced using regression model. Several experiments were also conducted in the farmers' fields.

The study showed that agroforestry practices varied in different upazilas of the northern part of Bangladesh. In Kaharole upazila, nine categories of agroforestry practices were recorded based on the presence of perennial tree species. Mixed home garden 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. In Jaldhakaupazila, 13 major categories of practices were identified out of 60 practices studied. The names with number of practices were mixed home garden (23), eucalyptus(12), mango+ litchi (6), mango(5), jackfruit (3), ghoraneem (3) and number (1) were malta, lemon, eucalyptus + mahagoni, eucalyptus + ghoraneem, betel nut, bay leaf based agroforestry systems. In Panchbibi upazila, 11 major categories of practices were identified. Mixed home garden occupied the highest number (29) followed by eucalyptus (7), mango (5), mahogoni (5), eucalyptus + akashmoni (3), eucalyptus + mahogony (2), litchi (2) and lowest number (1) was mango+ litchi, mango + mahogoni, jhingon + betel leaf, ghoraneem. In Gurudaspur upazila, 4 major categories of practices were identified out of 60 practices studied. The names and numbers of practices were mango (12), mango +litchi (5), litchi (18) and mixed garden (25).

From the study in Kaharole, Jaldhaka, Panchbibi and Gurudaspur upazila, results of the net income indicated that orchard agroforestry system was financially more profitable than cropland and homestead agroforestry systems, From the analysis of Panchbibi upazila it was recorded that net income of orchard agroforestry system was highest and in homestead agroforestry system net income was lowest. Benefit cost ratio of orchard agroforestry system was highest because here cost was less but benefit was more. From the results of Gurudaspur upazila it can be concluded that the income, net income and benefit cost ratio was highest in orchard agroforestry system compared to homestead and cropland agroforestry systems in Gurudaspur upazila under Natore district. Same results were obtained in the field experiments also. Among the different categories of agroforestry practices, most profitable practices were varied in places, e.g. highest profitable practice was mango and guava in Kaharole upazila, betel nut was in Jaldhaka, mahogany + eucalyptus was in Panchbibi upazila and mango+ litchi was in Gurudaspur upazila. In spite of higher BCR of homestead agroforestry, farmers in the study area widely practiced the orchard agroforestry. It appears that the farmers' decision regarding what kind of land use they will adopt depends not on the BCR, but largely on the net amount of income that they earn. As orchard agroforestry system provided more net income in spite of its higher initial cost, policy makers should give initial loan and provide quality planting materials to the farmers to grow profitable orchard agroforestry to get maximum benefit from a unit piece of land for northern part of Bangladesh.

## CRG Sub-Project Completion Report (PCR)

### A. Sub-project Description

1. **Title of the CRG sub-project:** Identification and economic analysis of existing agroforestry practices in the northern region of Bangladesh for better agroforestry practices
2. **Implementing organization:** Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh
3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

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4. **Sub-project budget (Tk):**
  - 4.1 Total: Tk=24,16,410/- (Taka twenty four lac sixteen thousand four hundred ten only)
  - 4.2 Revised (if any): Tk= 21,52,953/- (Twenty one lac fifty two thousand nine hundred fifty three only)

5. **Duration of the sub-project:**

Start date (based on LoA signed): 07 May 2017

5.1 End date: 30 September 2018

6. **Justification of undertaking the sub-project:**

There were many small chunks of natural forests in the northern part of Bangladesh. People would meet their demand of wood from those forests. Due to deforestation of these natural forests, people are now practicing different agroforestry programs increasingly in their homesteads, orchards and croplands for their own purposes. These agroforestry practices are not stable but changing. Previously people would plant native species. Now they are practicing with fast growing exotic species like Eucalyptus, Akashmoni, Ghora neem etc. On the other hand, due to lack of information, farmers usually

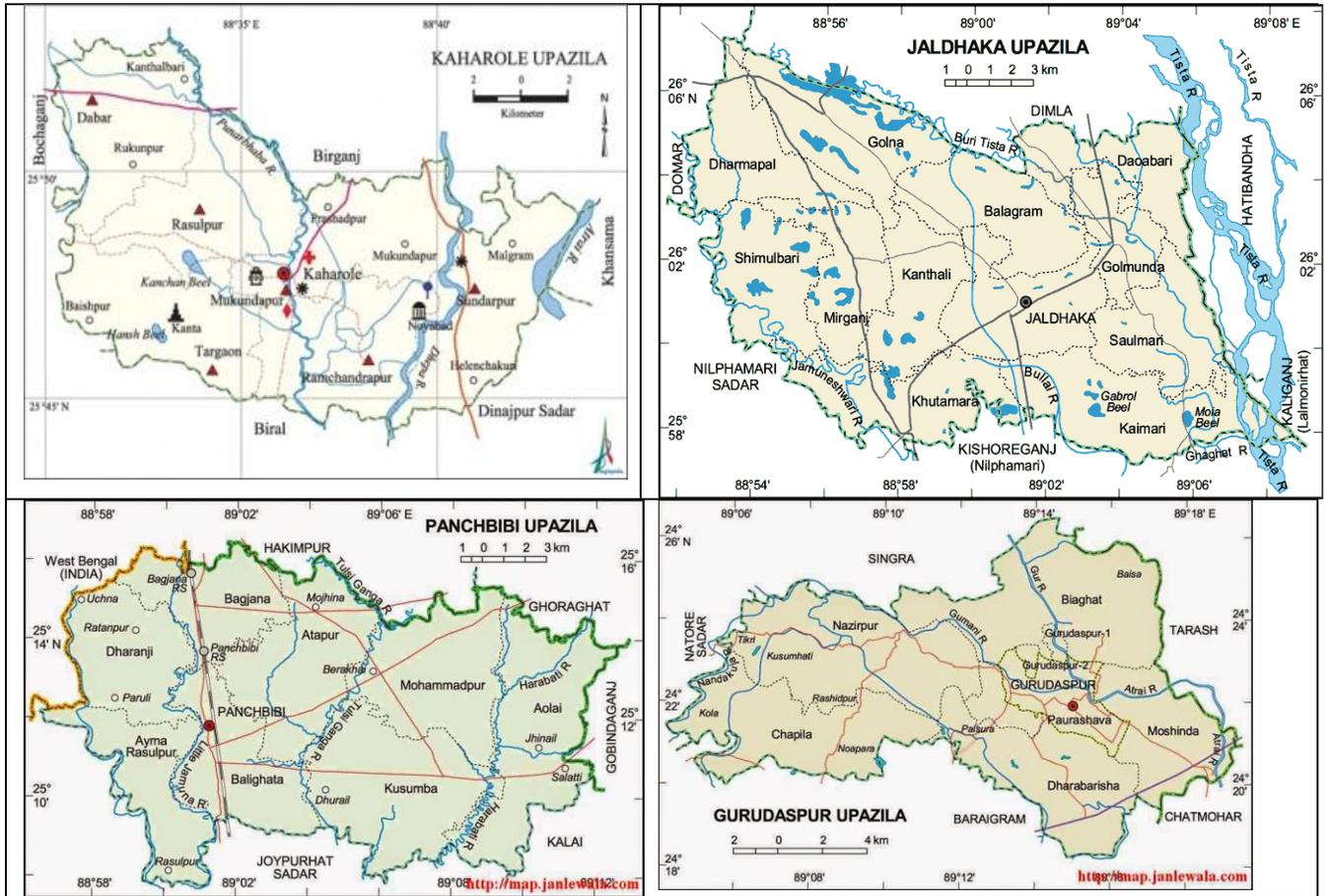
practices same agroforestry tree-crop combinations with different spacings as their wish. Beside these, people also planting various trees in their fields on the basis of their indigenous knowledge. But some of these combinations are profitable and some may not be profitable. This is happening due to inadequate research on the economic suitability of the agroforestry practices in different lands. Many researchers worked on the economic evaluation but researches considering spacing, species and land utility are lacking. So, it is necessary to find out the traditional, introduced, farmer-innovated agroforestry practices in the northern region of Bangladesh with their economic, financial and environmental suitability. This will help to screen out the suitable existing practices and also help to develop improved agroforestry practices for the well-being of the farmers and the country as well.

- 7. Sub-project goal:** To increase the productivity of agroforestry practices through improved technologies.
- 8. Sub-project objective (s):**
  - a) To identify and document the existing agroforestry practices of northern part of Bangladesh
  - b) To analyze economic value of the existing agroforestry practices
  - c) To suggest improved agroforestry practices for the farmers
- 9. Implementing location (s):** Dinajpur, Nilphamari, Natore, Joypurhat districts and Department of agroforestry and Environment, HSTU, Dinajpur.

## **10. Methodology in brief**

### **10.1 Experimental area**

Four Upazilas of Rangpur and Rajshahi divisions namely Kaharole, Jaldhaka, Panchbibi and Gurudaspur were selected for the work plan to conduct in-depth field survey, field measurement and field experiments to get basic information about the existing traditional and modern agroforestry systems practiced in the area, socio economic conditions of the farmers, plant species diversity, input costs and output benefits. From the result of the survey and experiments, data of targeted cropland, homesteads and orchards were analyzed.



**Fig1:** Map of Kaharole, Jaldhaka, Panchbibi and Gurudaspur upazila showing the study area.

**Table1:** Study area of Kaharole upazila under Dinajpur District

Sl No.	Sampled Unions	Sampled Villages	Systems	Total practices
1	2 No. Rasulpur	Rasulpur, Moheshpur, Baharpur, Nalapur Chandipur	Homestead, Orchards, Cropland	Mango based, Litchi based, Mahogany eucalyptus based, Mixed home garden
2	3.No. Mukundapur	Mukundapur, Dohonda, Pouria	Homestead, Orchards, Cropland	Mango based, Litchi based, Mahogany eucalyptus based, Guava based, Mixed home garden
3	5 No. Sundorpur	Gornurpur, Purboshadipur, Helenchakuri, Sundorpur	Homestead, Orchards, Cropland	Mango based, Litchi based, Mahogany, eucalyptus based, Guava based, Jujube based, Mixed home garden
4	6 No. Ramchandapur	Nayabad, Poromeshoripur, Mitrabati, Saranja, Ishanpur	Homestead, Orchards, Cropland	Mango based, Litchi based, Mahogany eucalyptus based,

**Table 2:** Study area of Jaldhaka upazila under Nilphamari District

Sl. No.	Sampled unions	Sampled Villages	Systems	Total practices
01	Koimari	Koimari bazar, Dighirpar, Kablia para, Dangapara, Bamon para	Homestead, Orchards and Cropland	Mixed Home garden, Eucalyptus based practices
02	Shoilmari	Shail para, Munshi para, Master para, Bashdaho, 4 no. taluk	Homestead, Orchards and Cropland	Mixed Home garden, Mango+Eucalyptus based
03	Daobari	Nekbokto, Khutipara, Siddheshori, Majapara	Homestead, Orchards and Cropland	Mixed Home garden, Eucalyptus based
04	Golna	Kaligonj, Chakamari, Tatipara, Dighirpar, Kharija	Homestead, Orchards and Cropland	Mixed Home garden, Betel nut based, Eucalyptus based, Ghoraneem based, Eucalyptus+Mahogany based

**Table 3:** Study area of Panchbibi upazila under Joypurhat District

Sl. No	Sampled Unions	Sampled Villages	Systems	Practices found
01	Dhoronji	Thangapara, Baguan, Guapara, Makatta, Taspur	Homestead, Orchards and Cropland	Eucalyptus based, Mixed based
02	Balighata	Sultanpur, Pocchim birnagar	Homestead, Orchards and Cropland	Litchi based, Mahogany based
03	Bagjana	Chesra, Ramvodropur, Tirpura mouja	Homestead, Orchards and Cropland	Litchi based, Mango based
04	Aima-Rosulpur	Koria, Lokma, Chairmanpara, Poschim koria	Homestead, Orchards and Cropland	Mixed based

**Table 4:** Study area of Gurudaspur upazila under Natore district

Sl#	Sampled Unions	Sampled Villages	Systems	AGF practices
1	Najirpur	Mamudpur, Bergangrampur, Zumainagar, Ikri	Homestead, Orchards and Cropland	Litchi based
2	Biaghat	Dastanagar, Kumerkhali, Biaghat,	Homestead, Orchards and Cropland	Litchi + Mango based
3	Darabarisha	Uttarnaribari, Sitoli, Darabarisha, Binnabari, Dakhin naribari	Homestead, Orchards and Cropland	mango based
4	Masinda	<i>Mersindakandipara, Jhaupara, Roynabhorot, Marsinda</i>	Homestead, Orchards and Cropland	Litchi based

### 10.2 Sampling Design

This study follows a multistage random sampling procedure. Firstly, a district is purposively selected from the northern region of Bangladesh. Consequently, out of upazilas (sub-districts) in the district, one Upazila is randomly selected. Out of unions of a Upazila, a total of four unions were 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.

### 10.3 Selection of farms/homesteads

About 30 agroforestry practices were surveyed for the first half year. Among the practices in each upazila, croplands, homesteads and orchards were brought under evaluation based on their input costs and output benefits.

#### **10.4 Expenditure data collection**

Expenditure data was collected from the owner of the practices, year wise expenditure data was collected from the farmer. The price of input materials was verified from different farmers. Labors requirement varies from seasons to season. Collecting information from the farmer, average labor requirement for per day was calculated and multiplied by 365 days to get labor requirements per year. By this way per year expenditure cost was calculated for all items. Chemical fertilizer cost includes urea, phosphate etc for a year. Irrigation equipment cost (Shallow machine, electric motor is used for agroforestry and other agricultural purpose, cost of irrigation equipment for study practices by the following formula.

#### **10.5 Returns data collection**

Output/ returns or sources of benefits which includes production sale in different years/seasons and estimated cost of existing products were recorded through discussion with the household personnel.

#### **10.6 Social data**

Social qualitative data such as gift of agroforestry products to neighbors, kith and kin were collected and quantified from the agroforestry farmers by means of their level of satisfaction.

#### **10.7 Tree measurement**

The height was measured by direct and instrumental method for small trees direct measured was done by the help of measuring tape for taller trees instrumental was used to measure the height. For our experiment, Haga altimeter was used to measure the height. The formula to calculate the height by Haga altimeter is, Height =Top reading –base reading from a specified position or scale (e.g. 15m , 20m, 25 m etc) For bigger trees diameter was measured at 1.37 m height whereas for small trees base diameter was measured. Tree canopy size was measured from the tree base in both sides. Merchantable height was measured up to the stem whose diameter is 10 cm or girth 1.0 feet which is followed by forest department in Bangladesh.

#### **10.8 System and practice identification**

Agroforestry systems of this study were homestead, cropland and orchard. Within the systems, different practices were analyzed based on timber / fruit tree species (Kibria and Shaha, 2011). Data were collected from the practices and they were again categorized into three agroforestry systems.

## 10.9 Data analysis

Annual production cost and income of a farmer was measured in taka on the basis of his total yearly production (land preparation cost, labor cost etc.) and income (fruit, crop, timber etc). Net income was calculated by deducting the total cost of production from the gross income. Benefit cost ratio is the ratio of gross income to total cost of production. Three years cost and income data were collected and seven years data were forecasted with the help of regression line in MS Excel. 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)

In this experiment, normality test was done for income and costs data by the Kolmogorov–Smirnov test by SPSS Version 22. To get normal distribution, all income and cost data were transformed to natural logarithm (e-base) and tested for normality. After analysis of log transformed data, antilogarithmic data were presented.

## 11. 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, Jaldhaka, Panchbibi Upazila under Dinajpur, Nilphamari, Joypurhat and Natore districts.

### 11.1 Results of Kaharole upazila

#### 11.1.1 Cost of 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. Figure 2 shows the three years actual production costs and seven years forecasted production costs of homestead, cropland and orchard agroforestry of Kaharole upazila under Dinajpur district. First year production costs of homestead, orchard and cropland agroforestry were recorded Tk. 10854, Tk. 98987 and Tk. 90238 per hectare respectively. Gradually the production cost decreased over time in all the systems. Regression line shows the forecasted production costs from 4th year to 10 years. The trend lines indicate the minimum cost levels of homestead and orchard systems as 7 years and 5 years in cropland agroforestry systems. The forecasting model for homestead production cost is obtained as  $y = -2006x + 13530$ , for cropland as  $y = -22089x + 12157$  and for orchard as  $y = -22677x + 16810$ .

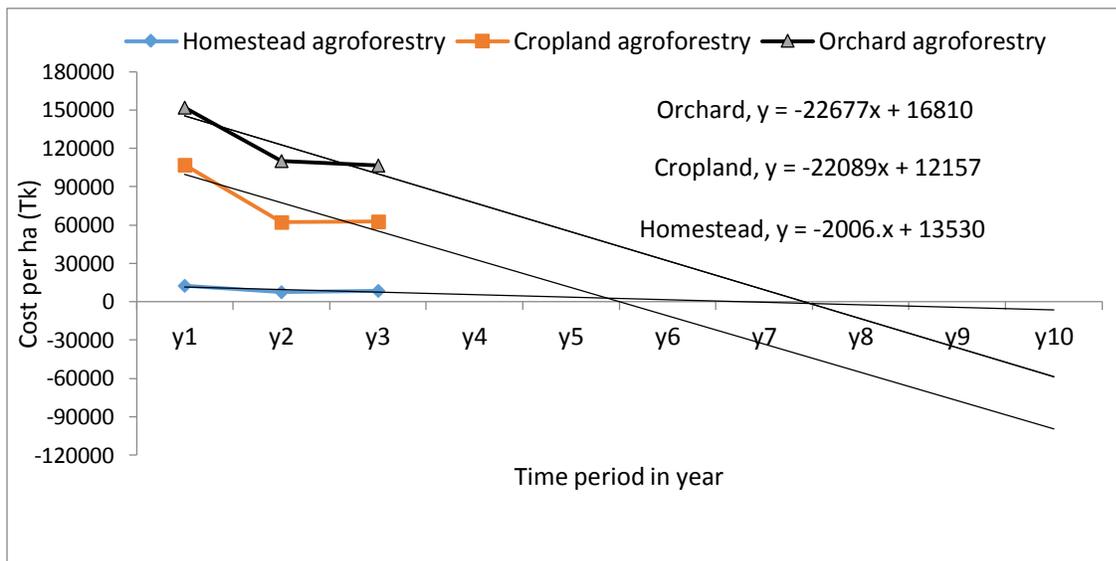


Figure 2. Production cost of homestead, cropland and orchard agroforestry systems of agroforestry of Kaharole upazila

### 11.1.2 Income of agroforestry systems

Figure 3 shows the gross income of homestead, cropland and orchard agroforestry systems of Kaharole upazila. First year gross income of homestead, cropland and orchard agroforestry was recorded Tk. 52027, Tk.157877 and Tk. 317888.47 per hectare respectively. Similarly second year gross incomes of homestead, cropland and orchard agroforestry were recorded as Tk.63223, Tk.157877 and Tk. 223225 per hectare respectively. Gradually the income increased over time in all the systems.

The trend line indicates the highest income of homestead, cropland and orchard agroforestry after tenth year as Tk. 234234, Tk. 251914 and Tk.564758 per hectare respectively. The regression equation of homestead, cropland and orchard income shows the positive trend of gross income in successive years.

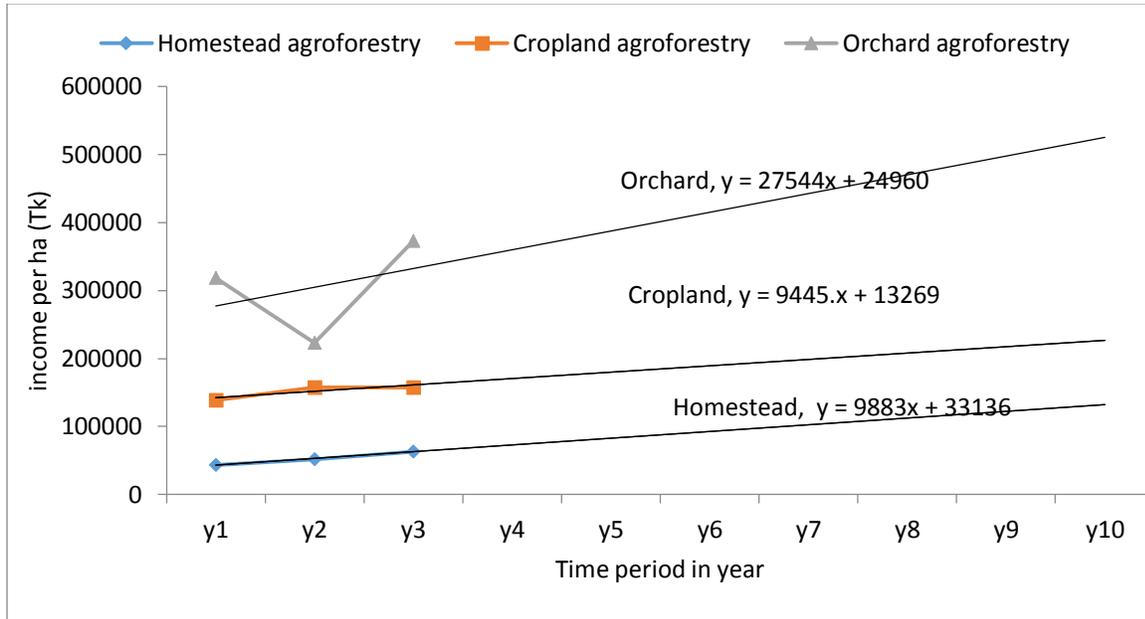


Figure 3. Gross income of agroforestry systems of Kaharole upazila

### 11.1.3 Net income of agroforestry systems

Figure 4 shows the gross income of homestead agroforestry of Kaharole upazila under Dinajpur district. First year net incomes of homestead, cropland and orchard agroforestry were recorded Tk. 32603, Tk. 48749 and Tk. 218902 per hectare respectively. Similarly, second year net incomes of homestead, cropland and orchard agroforestry was Tk. 45321, Tk. 84747 and Tk. 163954 per hectare respectively. The trend of net income was increased in subsequent years. Regression line shows the forecasted net income from 4<sup>th</sup> to 10<sup>th</sup> 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 shows the positive trend of net income in successive years for all the systems.

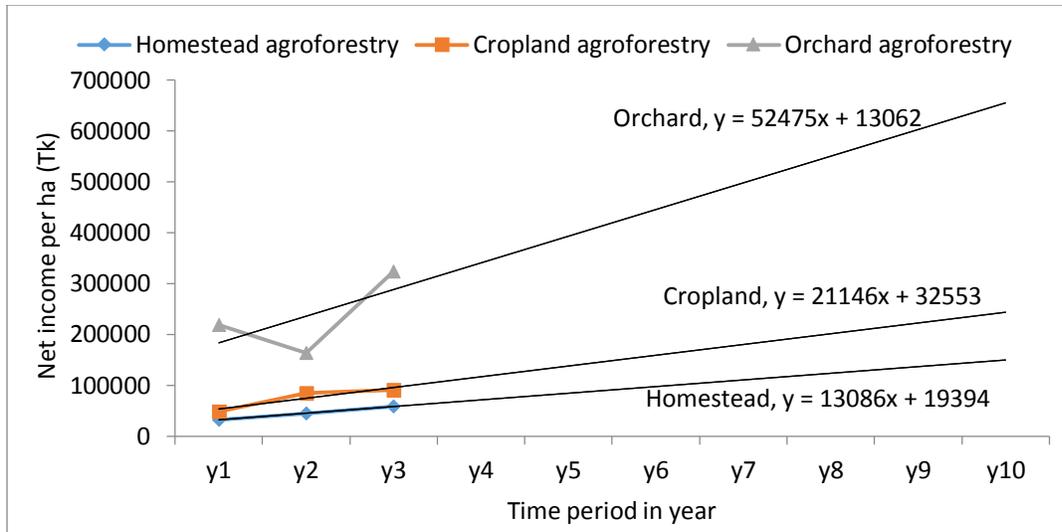


Figure 4. Net income of different agroforestry systems of Kaharole upazila

#### 11.1.4 BCR of agroforestry systems

Benefit cost ratio of agroforestry system or practice is the ratio between income and cost of the respective system or practice. The BCR of homestead, cropland and orchard agroforestry systems of Kaharole Upazila by using the natural log (Ln) transformed data is presented in figure 5.

First year benefit cost ratio was calculated for homestead, cropland and orchard as 3.16, 2.85 and 3.01 per hectare respectively. Similarly second year benefit cost ratio of homestead, cropland and orchard were 3.43, 2.99 and 3.01 respectively. Gradually the benefit cost ratio increased over time. From the regression line benefit cost ratios of homestead, cropland and orchard after 10 years were calculated as 6.68, 5.23 and 3.12. The trend line indicates the highest benefit cost ratio of homestead agroforestry after 10 years 6.68. The regression model of BCR of homestead, cropland and orchards are shown in figure 5.

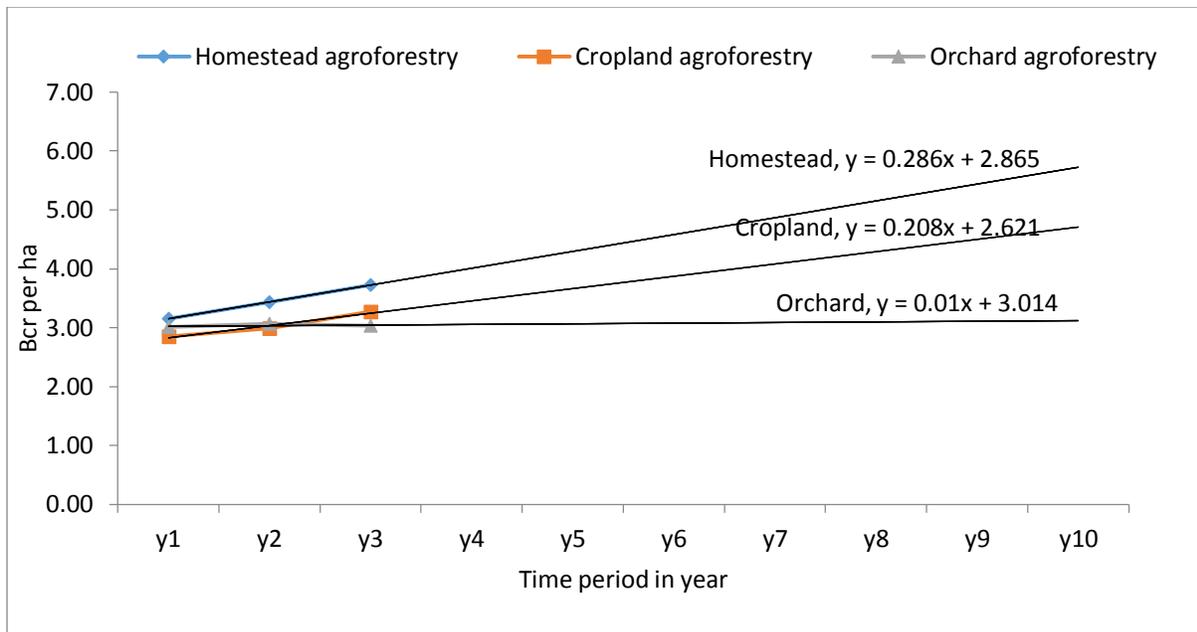


Figure 5. Benefit cost ratio of different agroforestry systems of Kaharole Upazila

### 11.1.5 Costs of agroforestry practices

Agroforestry practices are the different tree based practices within the systems. Figure 6 presents the natural log (LN) data of three years cost of different agroforestry practices of Kaharole upazila. In the first year, highest production cost was recorded in guava based practice followed by jujube, mango +litchi, only mango, mahogany, eucalyptus +mahogany eucalyptus, litchi 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.

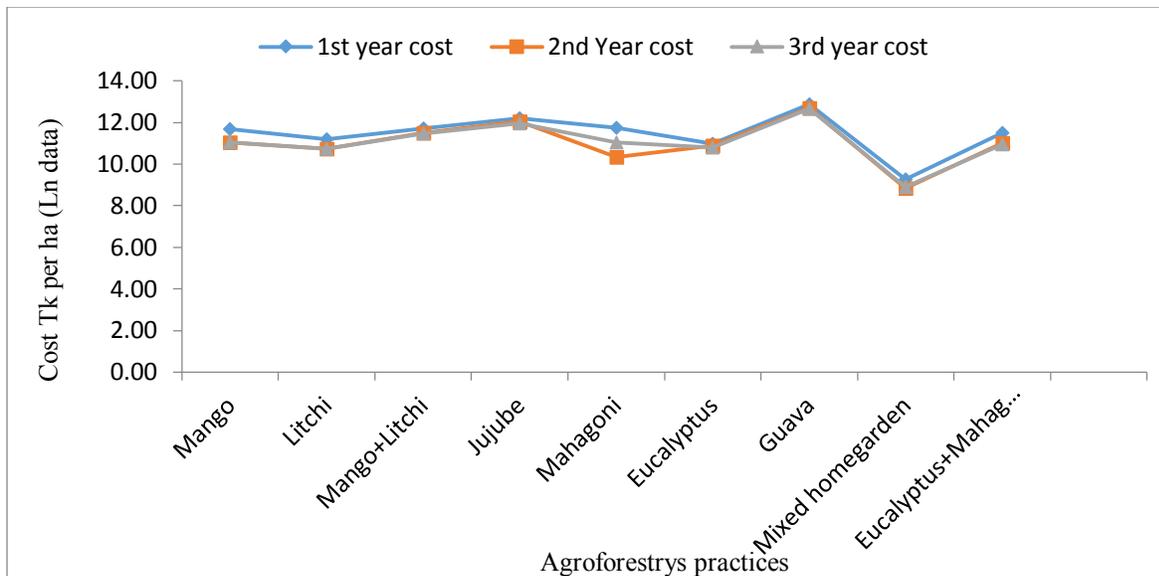


Figure 6. Production costs of different agroforestry practices of Kaharole Upazila (Natural log transformed data)

### 11.1.6 Income of agroforestry practices

Figure 7 presents three years income of different agroforestry practices of Kaharole Upazila. In the first year, highest income was recorded in guava based agroforestry practice followed by eucalyptus + mahogany, mango, eucalyptus mahogany, mango + litchi, litchi, mixed home garden and the lowest cost was found in jujube practices. Same trend of cost was recorded in the second and third years for all the practices (Figure 7).

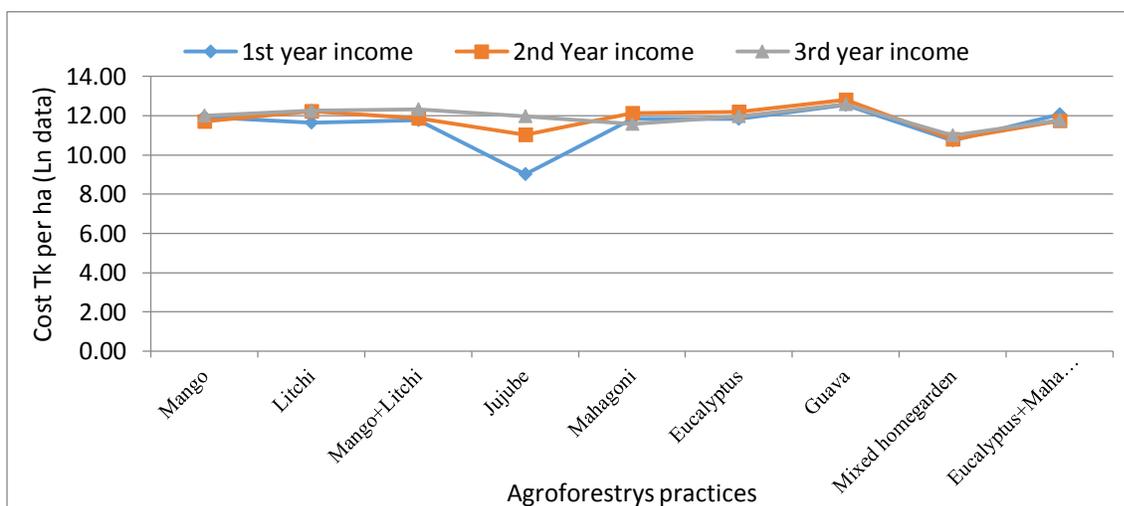


Figure 7. Income of different agroforestry practices of Kaharole upazila

### 11.1.7 Net income of agroforestry practices

Figure 8 presents three years income of different agroforestry practices of Kaharole Upazila. In the first year, highest net income was recorded in eucalyptus based agroforestry practice followed by mixed based guava, mango, eucalyptus + mahogany, mahogany, mango + litchi, litchi, mixed and the lowest net income was found in jujube practices. In second year, highest net income was recorded in mahogany based agroforestry and lowest net income was recorded in jujube based 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.

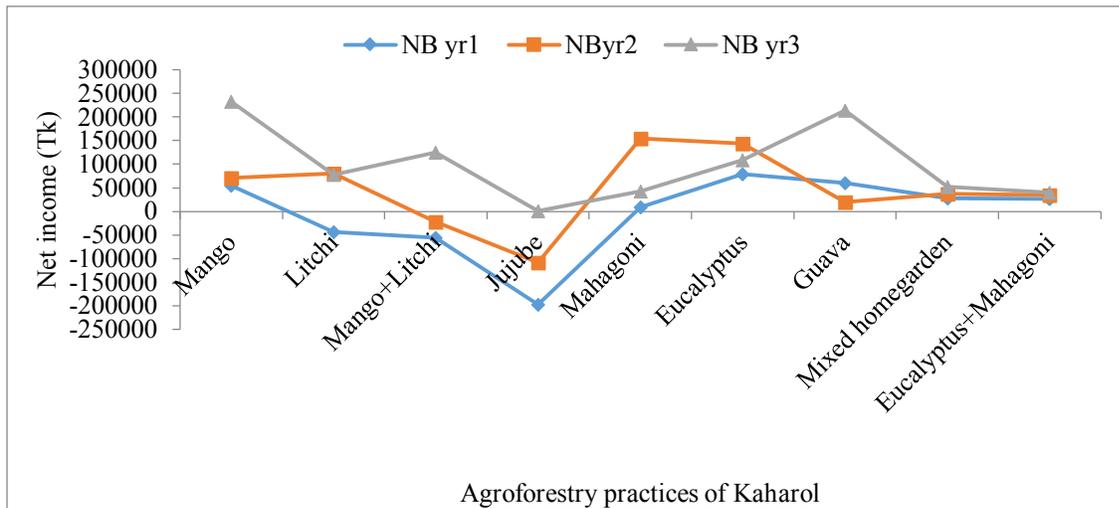


Figure 8. Net income of different agroforestry practices of Kaharole upazila.

### 11.1.8 BCR of agroforestry practices

Figure 9 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 + mahagoni, eucalyptus, litchi, guava, mango, mango + litchi, mahogany and the lowest benefit cost ratio was found in jujube practices. Same trend of benefit cost ratio was recorded in the second and third years for all the practices (Figure 8).

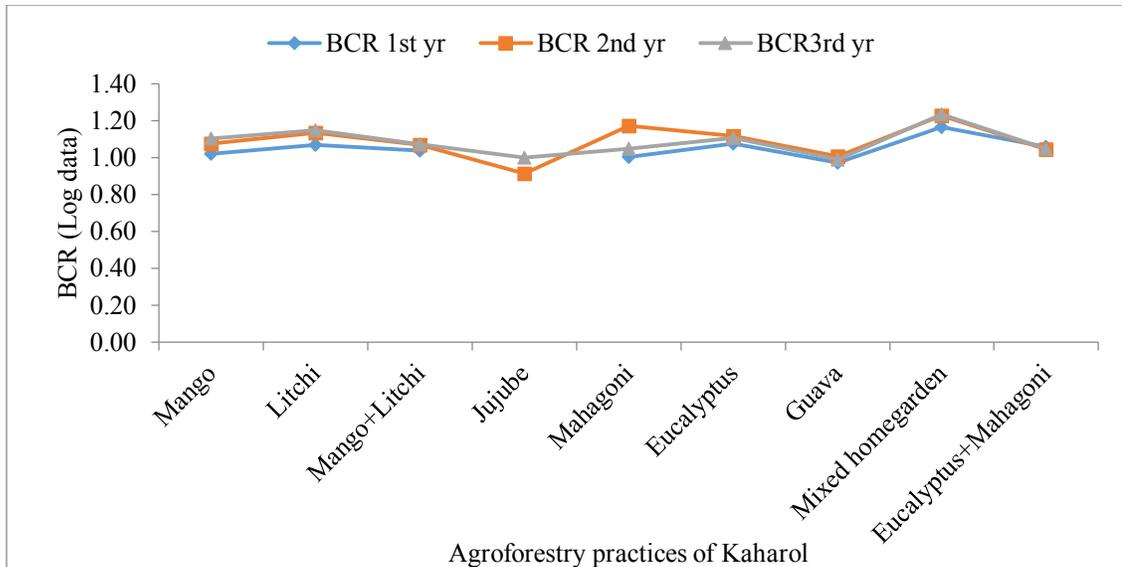


Figure 9. Benefit cost ratio of different agroforestry practices of Kaharole Upazila

#### 11.1.9 Identification of 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 home garden occupied the highest number (21) followed by Litchi (14), Mango (12) based practices and lowest number was recorded in Eucalyptus (1), Jujube (1), Mahagoni (1) based practices (Figure 10).

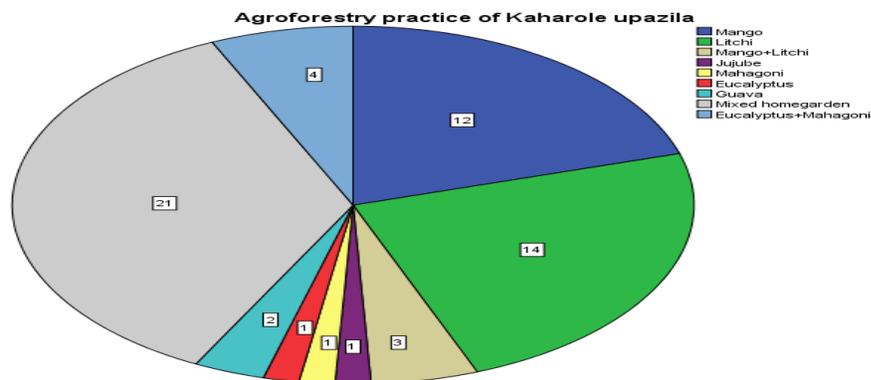


Figure 10 Number of agroforestry practices of Kaharole upazila

11.1.10 Photo plates of Kaharole upazila



Plate 1. Mango based cropland agroforestry



Plate 2. Eucalyptus+ Litchi based agroforestry



Plate 3. Mango +Pointed gourd cropland



Plate 4. Mango+ Guava based agroforestry

Plate 1-4: Different agroforestry practices of Kaharole upazila of Dinajpur district

## 11.2 Results of Jaldhaka upazila

### 11.2.1 Cost of agroforestry systems

Figure 11 shows the cost of homestead agroforestry of Jaldhaka Upazila under Nilphamari district. First year cost of homestead agroforestry was recorded Tk. 21280 per ha. Gradually the cost was decreased. Second and third year costs were similar. Regression line shows the forecasted cost up to ten years. The trend line indicated the lowest cost of homestead after ten years (Tk. 1875 per ha). Here regression equation was obtained as ,  $y = -1876.8x + 18249$ ..... (1)

Equation (1) shows the negative trend of cost in successive years. The intercept of the equation also indicates that initial establishment cost Tk. 18249 may be needed for a one hectare homestead. The value of  $R^2 = 0.8649$  indicated the change of a year (independent variable) changes the cost of homestead (dependent variable) to 0.864 or 86.4% (Figure 11).

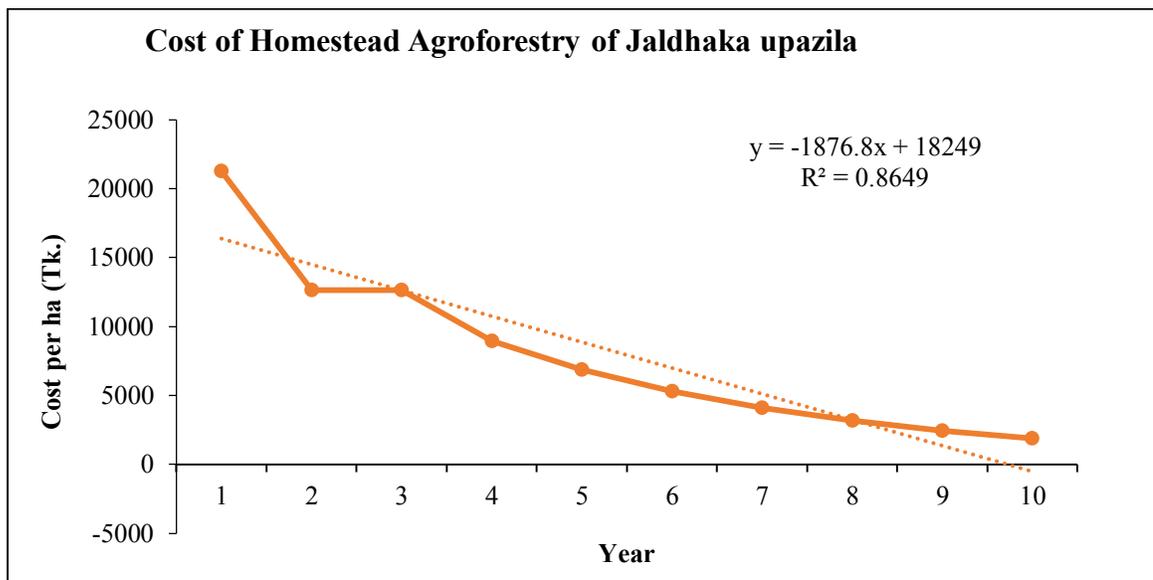


Figure 11: Cost of homestead agroforestry of Jaldhaka upazila

Figure 12 shows the cost of orchard agroforestry of Jaldhaka upazila under Nilphamari district. First year cost of orchard agroforestry was recorded Tk. 118836 per ha. Gradually the cost was decreased. Second and third year costs were Tk. 72693 and Tk. 12645. Regression line shows the forecasted cost up to ten years. The trend line indicated the lowest cost of orchard after ten years (Tk. 6 per ha). Here regression equation was obtained as,  $y = -10042x + 76404$ ..... (2)

Equation (2) shows the negative trend of cost in successive years. The value of  $R^2 = 0.5505$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here cost) to 0.5505 or 55.1% (Figure 12).

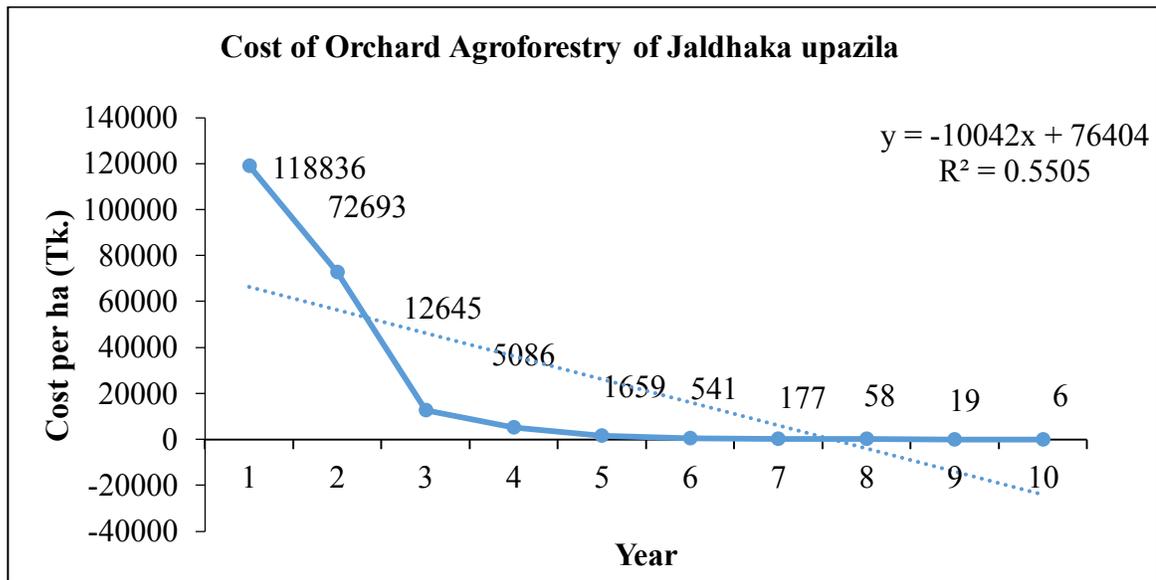


Figure 12: Cost of orchard agroforestry of Jaldhaka upazila

Figure 13 shows the cost of orchard agroforestry of Jaldhaka upazila under Nilphamari district. First year cost of orchard agroforestry was recorded Tk. 145002 per ha. Gradually the cost was decreased. Second and third year costs were Tk. 124617 and Tk. 12645. Regression line shows the forecasted cost up to ten years. The trend line indicated the lowest cost of orchard after ten years (Tk. 3.5 per ha). Here regression equation was obtained as  $y = -13678x + 104214$ ..... (3)

Equation (3) shows the negative trend of cost in successive years. The value of  $R^2 = 0.5445$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here cost) to 0.5445 or 54.45% (Figure 13).

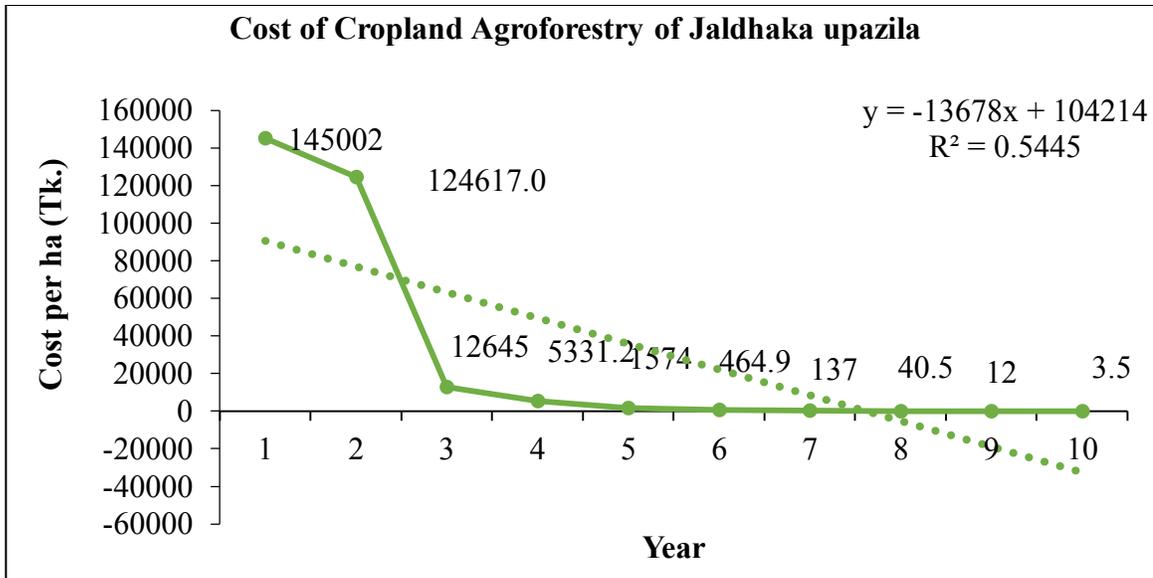


Figure 13: Cost of cropland agroforestry of Jaldhaka upazila

### 11.2.2 Cost of agroforestry practices

Figure 14 shows the cost of agroforestry practices of Jaldhaka upazila under Nilphamari district. In first year cost was highest in lemon and malta based agroforestry practice and lowest cost was in bay leaf based agroforestry practice. Second year cost was highest in Eucalyptus + Ghora neem based agroforestry practices and lowest in Mixed home garden based agroforestry practice. In third year cost was highest in Jackfruit based agroforestry practices and lowest cost was found in Bay leaf and Mixed home garden based agroforestry practices. Average highest cost was found in Eucalyptus + Ghora neem based agroforestry practices and lowest average cost was found in Bay leaf based agroforestry practices.

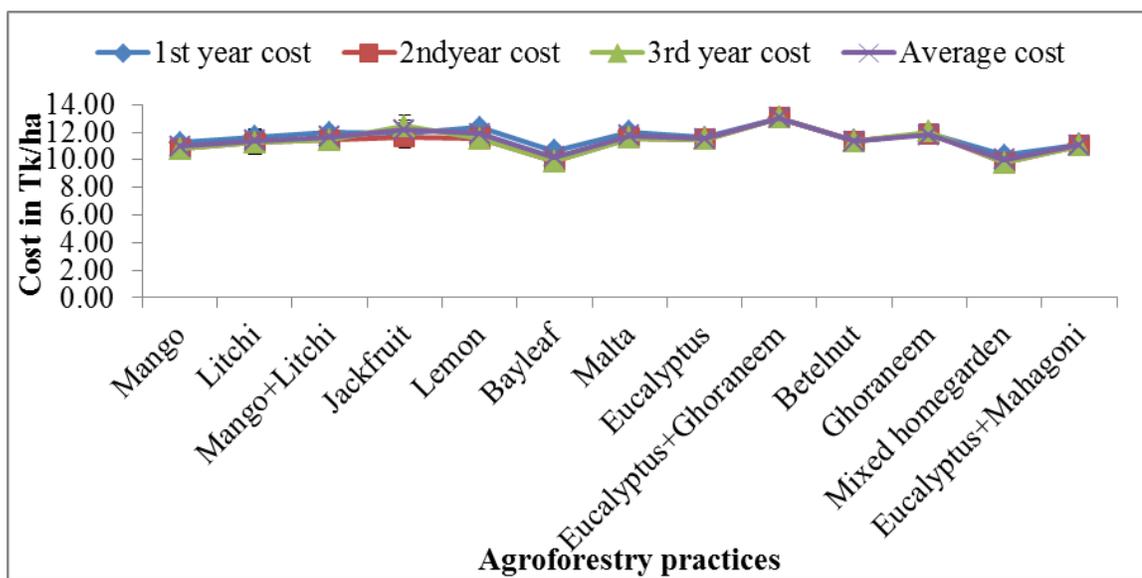


Figure 14: Cost of agroforestry practices of Jaldhaka upazila under Nilphamari district

### 11.2.3 Income of agroforestry systems

Figure 15 shows the income of homestead agroforestry of Jaldhaka Upazila under Nilphamari District. First year income of homestead agroforestry was recorded Tk. 3522 per ha. Gradually the income was increased. Second and third year income were Tk. 4398 and Tk. 26903 per ha. Regression line shows the forecasted income up to ten years. The trend line indicated the highest income of homestead after ten years (Tk. 25440472 per ha). Here regression equation was obtained as  $y = 2E+06x - 6E+06.....(4)$

Equation (4) shows the positive trend of income in successive years. The value of  $R^2 = 0.5087$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here “income”) to 0.5087 or 50.87%.

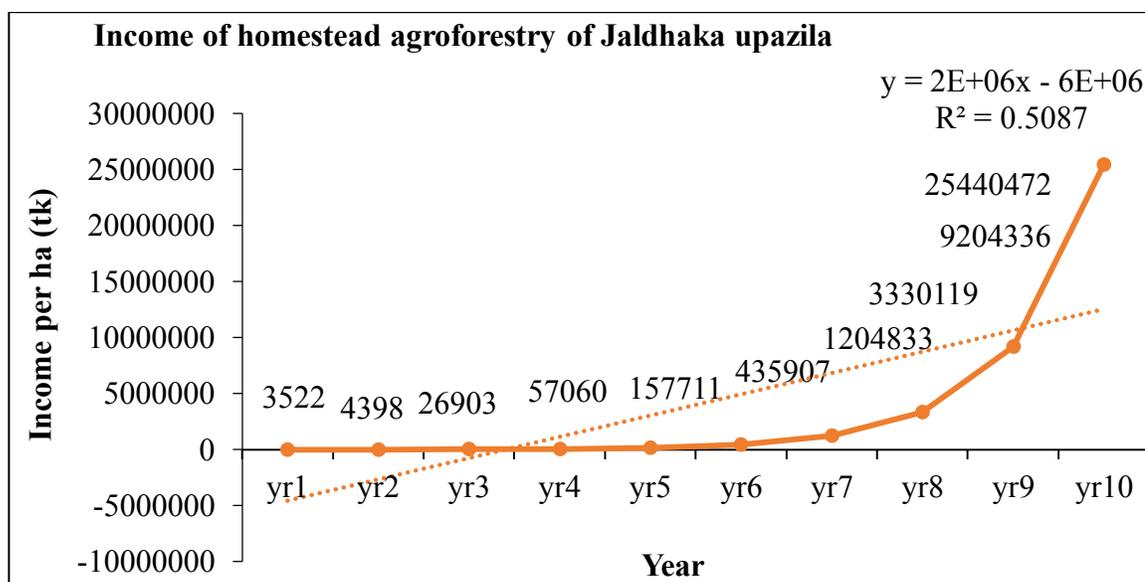


Figure 15: Income of homestead agroforestry of Jaldhaka upazila

Figure 16 shows the income of orchard agroforestry of Jaldhaka upazila under Nilphamari district. First year income of orchard agroforestry was recorded Tk. 7204 per ha. Gradually the income was increased. Second and third year income were Tk. 18463 and Tk. 40583 per ha. Regression line shows the forecasted income up to ten years. The trend line indicated the highest income of orchard after ten years (Tk. 17669735 per ha). Here regression equation was obtained as  $y = 1E+06x - 5E+06.....(5)$

Equation (5) indicates the positive trend of income in successive years. The value of  $R^2 = 0.5617$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here “income”) to 0.5617 or 55.17%.

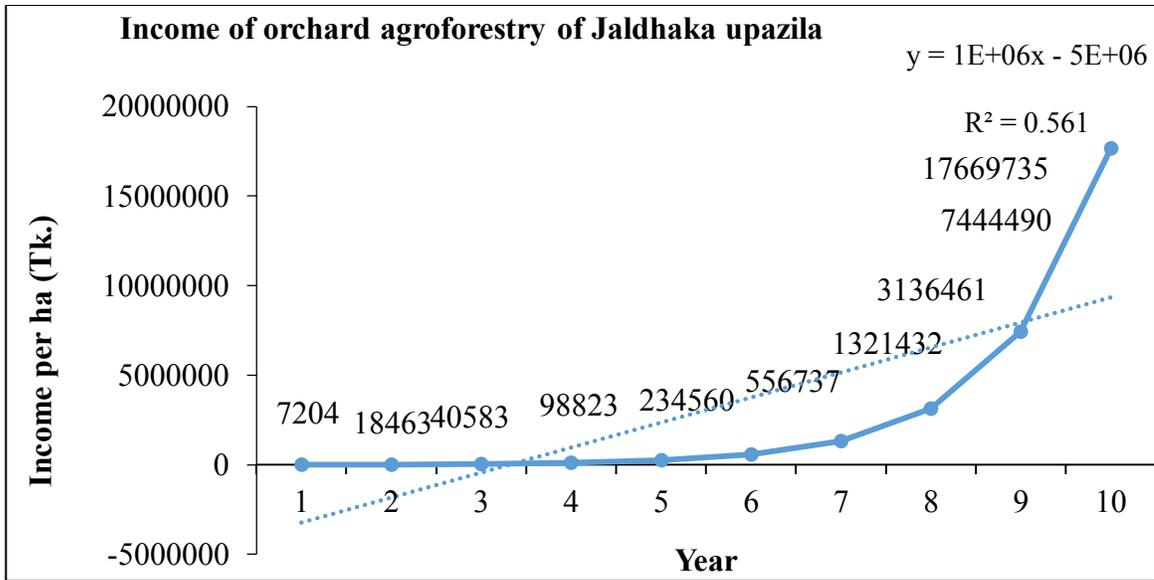


Figure 16: Income of orchard agroforestry of Jaldhaka upazila

Figure 17 shows the income of cropland agroforestry of Jaldhaka Upazila under Nilphamari district. First year income of cropland agroforestry was recorded Tk. 242802 per ha. Gradually the income was increased. Second and third year income were Tk. 255250 and Tk. 380789 per ha. Regression line shows the forecasted income up to ten years. The trend line indicated the highest income of cropland after ten years (Tk. 1735258 per ha). Here regression equation was obtained as  $y = 160098x - 109701$ ..... (6)

Equation (6) shows the positive trend of income in successive years.

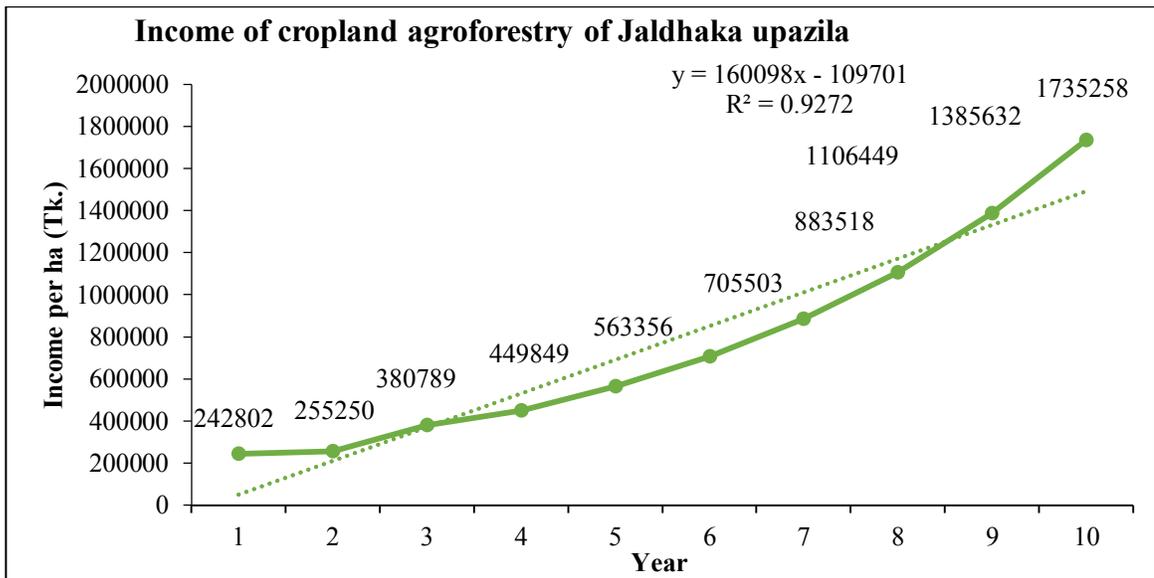


Figure 17: Income of cropland agroforestry of Jaldhaka upazila

### 11.2.4 Income of agroforestry practices

Figure 18 shows the income of agroforestry practices of Jaldhaka upazila under Nilphamari district. In first year income was highest in lemon based agroforestry practice and lowest income was in lemon and jackfruit based agroforestry practice. Second year income was highest in Eucalyptus +Ghora neem based agroforestry practices and lowest in litchi based agroforestry practice. In third year income was highest in Eucalyptus +Ghora neem based agroforestry practices and lowest cost was found in jackfruit based agroforestry practices. Average highest income was found in Eucalyptus +Ghora neem based agroforestry practices and lowest average income was found in jackfruit based agroforestry practices.

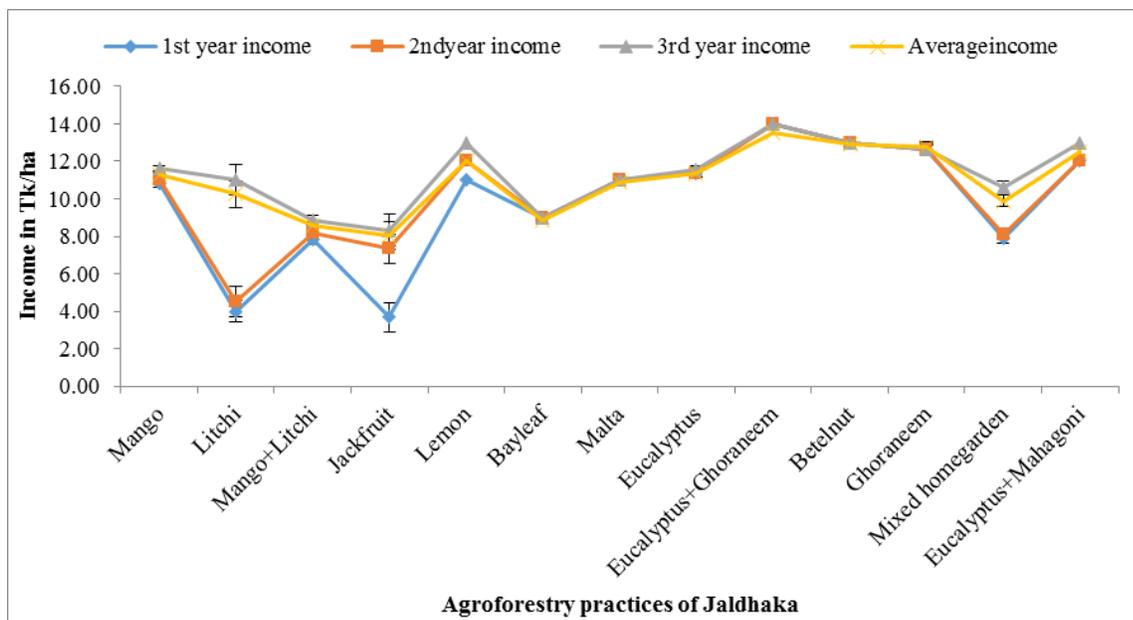


Figure 18: Income of agroforestry practices of Jaldhaka upazila under Nilphamari district

### 11.2.5 Net income of agroforestry systems

Figure 19 shows the net income of homestead agroforestry of Jaldhaka Upazila under Nilphamari district. First year net income of homestead agroforestry was recorded Tk. 0 per ha. Second and third year net income were Tk. 0.0 and Tk 2 per ha. Regression line shows the forecasted net income up to ten years. The trend line indicated the highest net income of homestead after ten years (Tk. 13566 per ha). Here regression equation was obtained as  $y = 937.98x - 3277.6$ ..... (7)

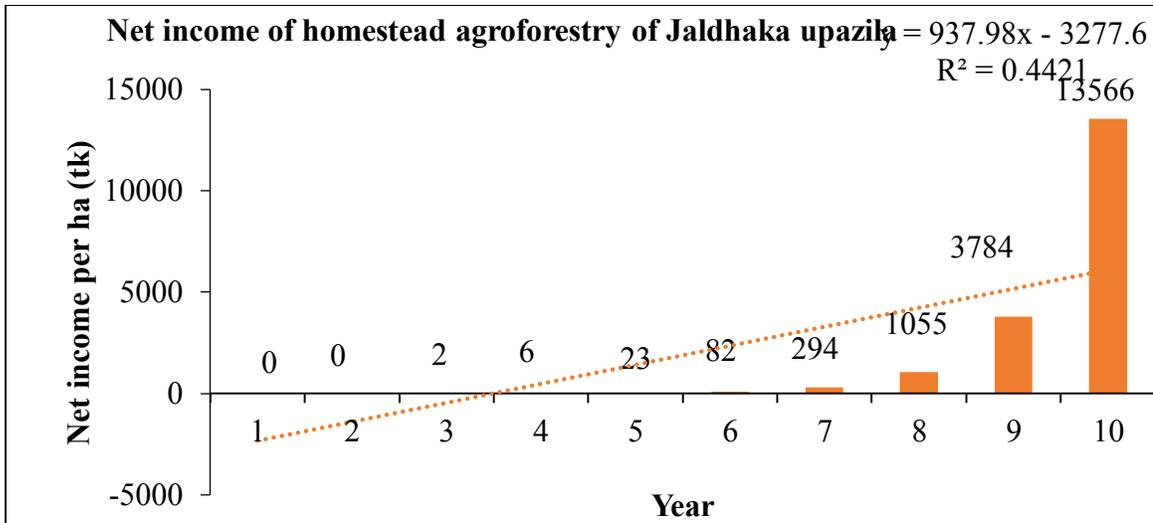


Figure 19: Net income of homestead agroforestry of Jaldhaka upazila

Figure 20 shows the net income of orchard agroforestry of Jaldhaka upazila under Nilphamari district. First year net income of orchard agroforestry was recorded Tk. 0 per ha. Second and third year net income were Tk 0.0 and Tk 3.0 per ha. Regression line shows the forecasted net income up to ten years. The trend line indicated the highest net income of orchard after ten years (Tk. 2883544 per ha). Here regression equation was obtained as  $y = 175888x - 633086$ ..... (8)

Equation (8) shows the positive trend of net income in successive years. The value of  $R^2 = 0.3469$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here “net income”) to 0.3469 or 34.69%.

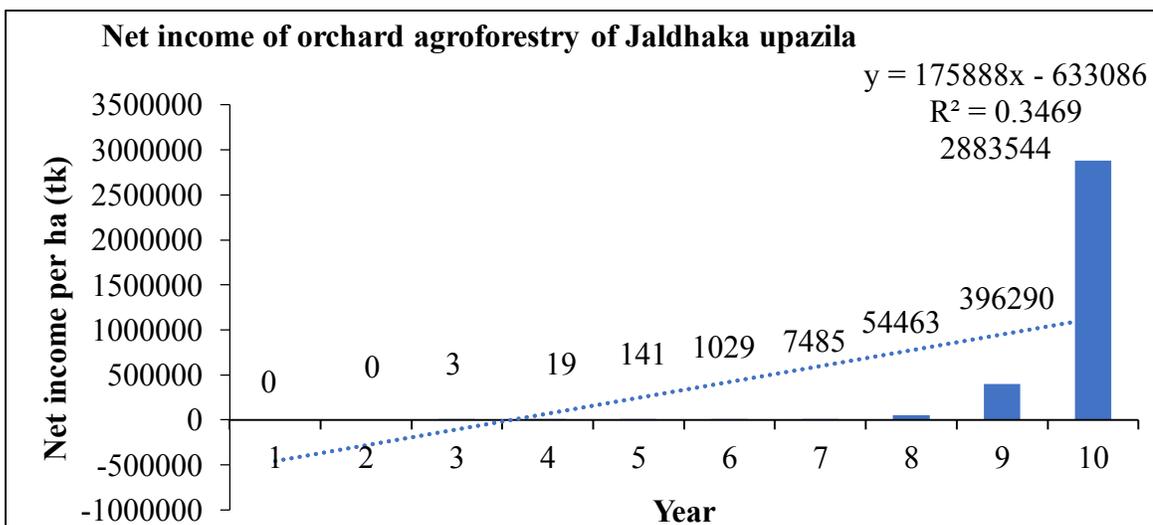


Figure 20: Net income of orchard agroforestry of Jaldhaka upazila

Figure 21 shows the net income of cropland agroforestry of Jaldhaka upazila under Nilphamari district. First year net income of cropland agroforestry was recorded Tk 2.0 per ha. Second and third year net income were Tk 2.0 and Tk 30.0 per ha. Regression line shows the forecasted net income up to ten years. The trend line indicated the highest net income of cropland after ten years (Tk. 490820 per ha). Here regression equation was obtained as  $y = 32631x - 115240$ ..... (9)

Equation (9) shows the positive trend of net income in successive years. The value of  $R^2 = 0.4108$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable to 0.4108 or 41.08%.

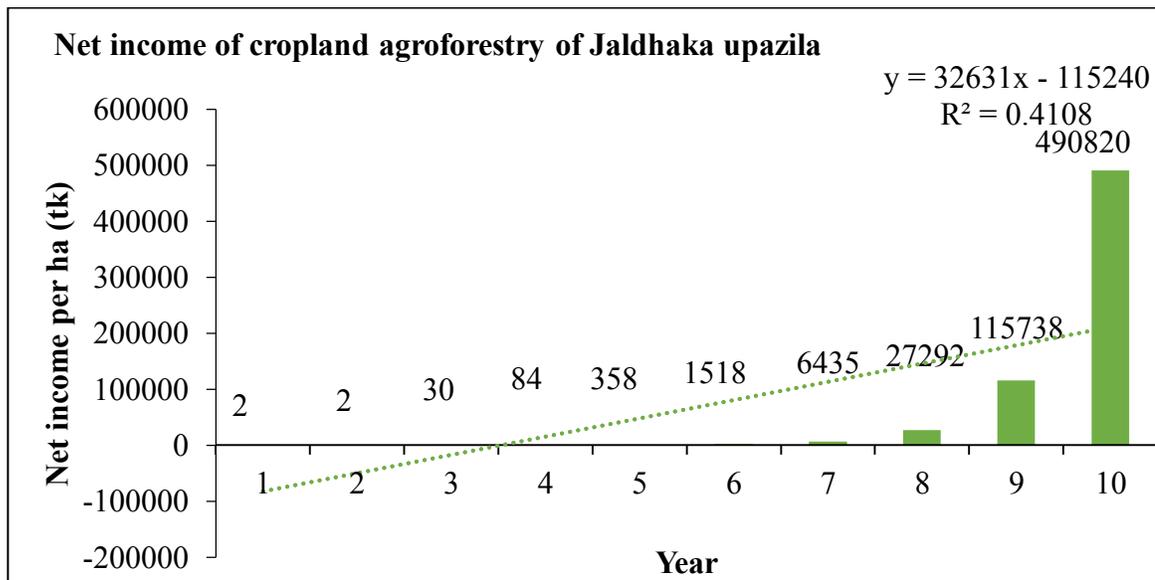


Figure 21: Net income of cropland agroforestry of Jaldhaka upazila

### 11.2.6 Net income of agroforestry practices

Figure 22 shows the net income of agroforestry practices of Jaldhaka upazila under Nilphamari district. In first year net income was highest in betel nut based agroforestry practice and lowest net income was in jackfruit based agroforestry practice. Second year net income was highest in betel nut based agroforestry practices and lowest in litchi based agroforestry practice. In third year net income was highest in Eucalyptus +mahogany and lemon based agroforestry practices and lowest net income was found in jackfruit based agroforestry practices. Average highest net income was found in betel nut based agroforestry practices and lowest average income was found in jackfruit based agroforestry practices.

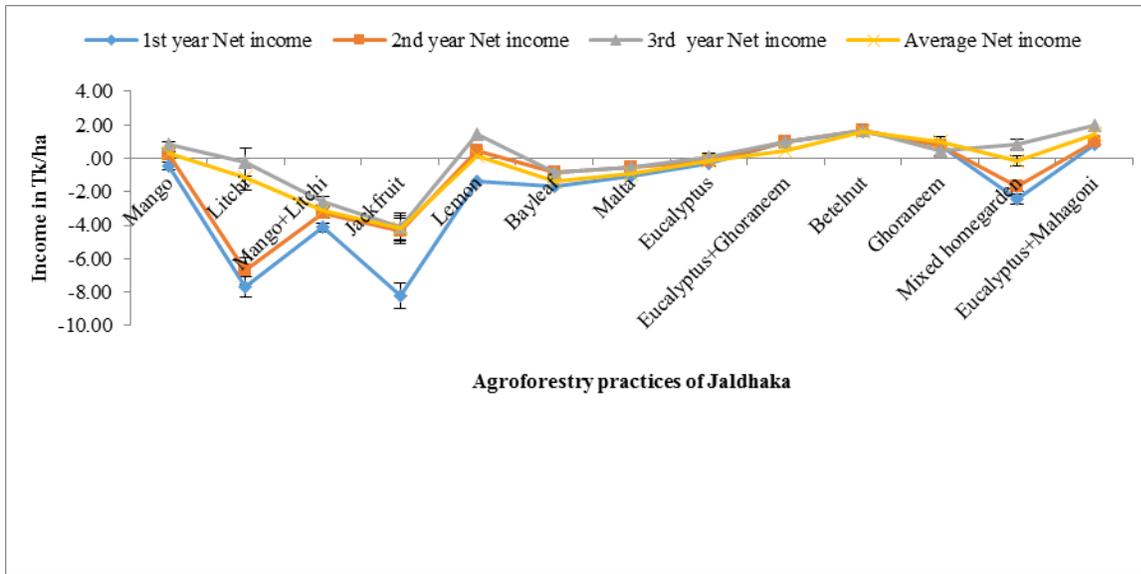


Figure 22: Net income of agroforestry practices of Jaldhaka

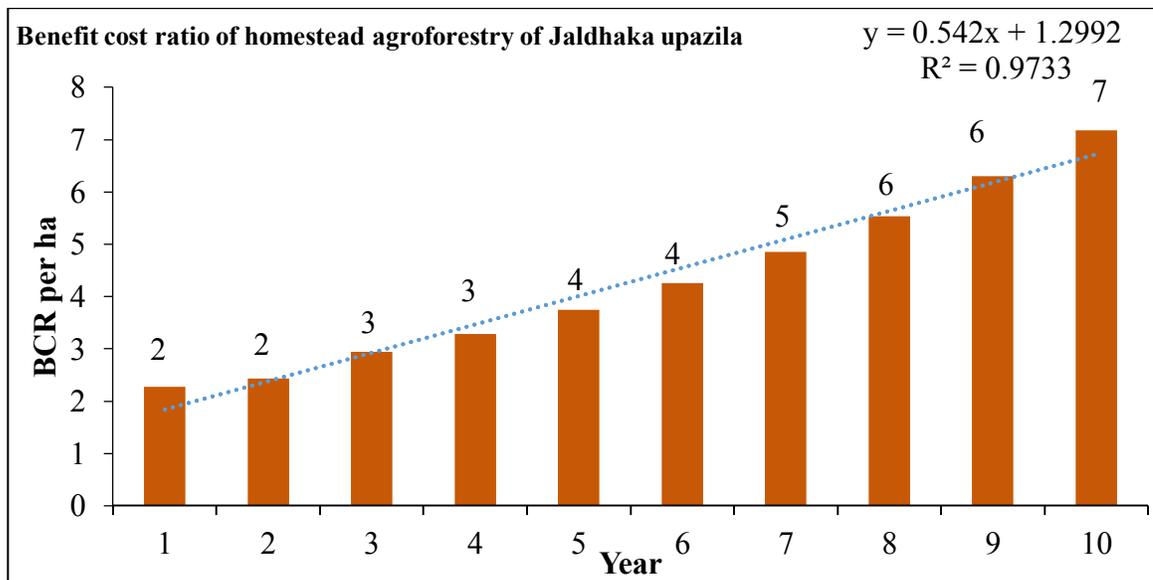


Figure 23: Benefit cost ratio of homestead agroforestry of Jaldhaka upazila

Initially benefit cost ratio of orchard agroforestry system was lower which was gradually increased.

Figure 24 shows the benefit cost ratio of orchard agroforestry of Jaldhaka upazila under Nilphamari district. First year benefit cost ratio of orchard agroforestry was recorded Tk. 2 per ha. Second and third year net income were Tk. 2 and Tk. 3 per ha. Regression line shows the forecasted benefit cost ratio up to ten years. The trend line indicated the highest benefit cost ratio of orchard after ten years (Tk. 11 per ha). Here regression equation was obtained as  $y = 0.9327x + 0.2834$ ..... (11)

Equation (11) shows the positive trend of benefit cost ratio in successive years. The value of  $R^2 = 0.9509$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here “benefit cost ratio”) to 0.9509 or 95.09%.

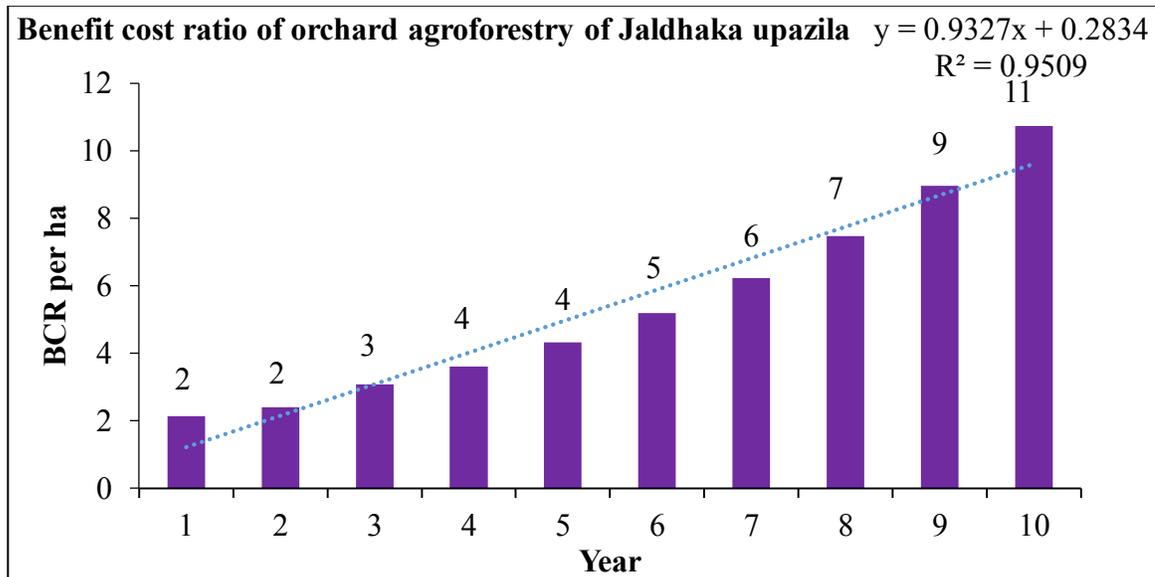


Figure 24: Benefit cost ratio of orchard agroforestry of Jaldhaka upazila

Initially benefit cost ratio of cropland agroforestry system was lower which was gradually increased.

Figure 25 shows the benefit cost ratio of cropland agroforestry of Jaldhaka upazila under Nilphamari district. First year benefit cost ratio of cropland agroforestry was recorded Tk. 3 per ha. Second and third year net income were Tk. 3 and Tk. 4 per ha. Regression line shows the forecasted benefit cost ratio up to ten years. The trend line indicated the highest benefit cost ratio of cropland after ten years (Tk. 11 per ha). Here regression equation was obtained as  $y = 0.9312x + 1.0008$ ..... (12)

Equation (12) shows the positive trend of benefit cost ratio in successive years. The value of  $R^2 = 0.9604$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here “benefit cost ratio”) to 0.9604 or 96.04%.

### 11.2.7 BCR of agroforestry systems

Initially benefit cost ratio of homestead agroforestry system was lower which was gradually increased.

Figure 23 shows the benefit cost ratio of homestead agroforestry of Jaldhaka upazila under Nilphamari district. First year benefit cost ratio of homestead agroforestry was recorded Tk. 2 per ha. Second and third year net

income were Tk. 2 and Tk. 3 per ha. Regression line shows the forecasted benefit cost ratio up to ten years. The trend line indicated the highest benefit cost ratio of homestead after ten years (Tk. 7 per ha). Here regression equation was obtained as  $y = 0.542x - 1.2992$ ..... (10)

Equation (10) shows the positive trend of benefit cost ratio in successive years. The value of  $R^2 = 0.9733$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here “benefit cost ratio”) to 0.9733 or 97.33%.

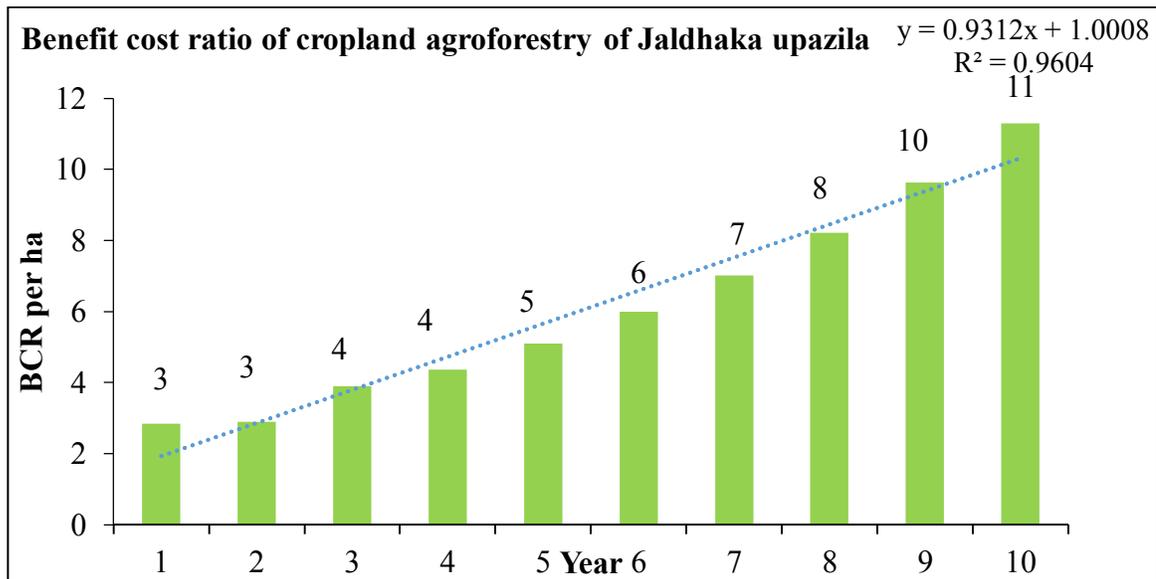


Figure 25: Benefit cost ratio of cropland agroforestry of Jaldhaka upazila

### 11.2.8 BCR of agroforestry practices

Figure 26 shows the benefit cost ratio of agroforestry practices of Jaldhaka upazila under Nilphamari district. Highest benefit cost ratio was found in betel nut based agroforestry practices and lowest benefit cost ratio was found in jackfruit based agroforestry practice.

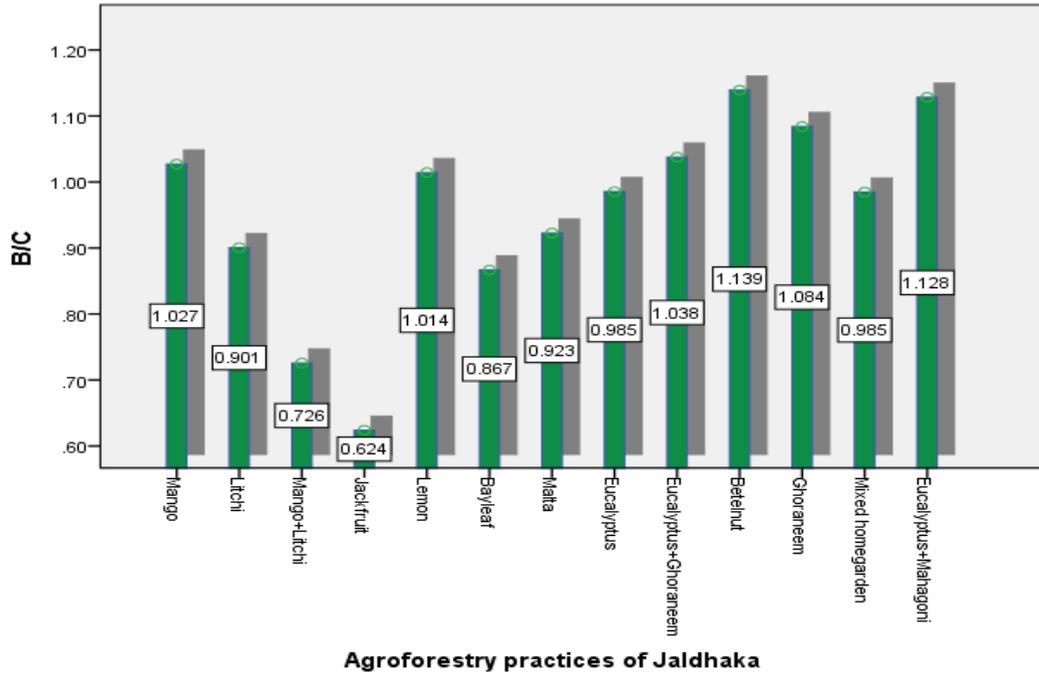


Figure 26: Benefit cost ratio of agroforestry practices of Jaldhaka

### 11.2.9 Identification of Agroforestry Practices

Different types of agroforestry practices were observed in Jaldhaka upazila. Total number of agroforestry practices was recorded in small (21) medium (10) large (17) and extra-large (12). Figure 4.16 presents different agroforestry practices of Jaldhaka upazila, Nilphamari. Among 60 agroforestry practices Mixed homegarden occupied the highest number(23) followed by Eucalyptus(12), Mango+ Litchi(6),Mango(5), Jackfruit(3), Ghora neem(3) and lowest number(1) was Malta, Lemon, Eucalyptus+Mahagoni, Eucalyptus+Ghora neem, Betel nut, Bay leaf.

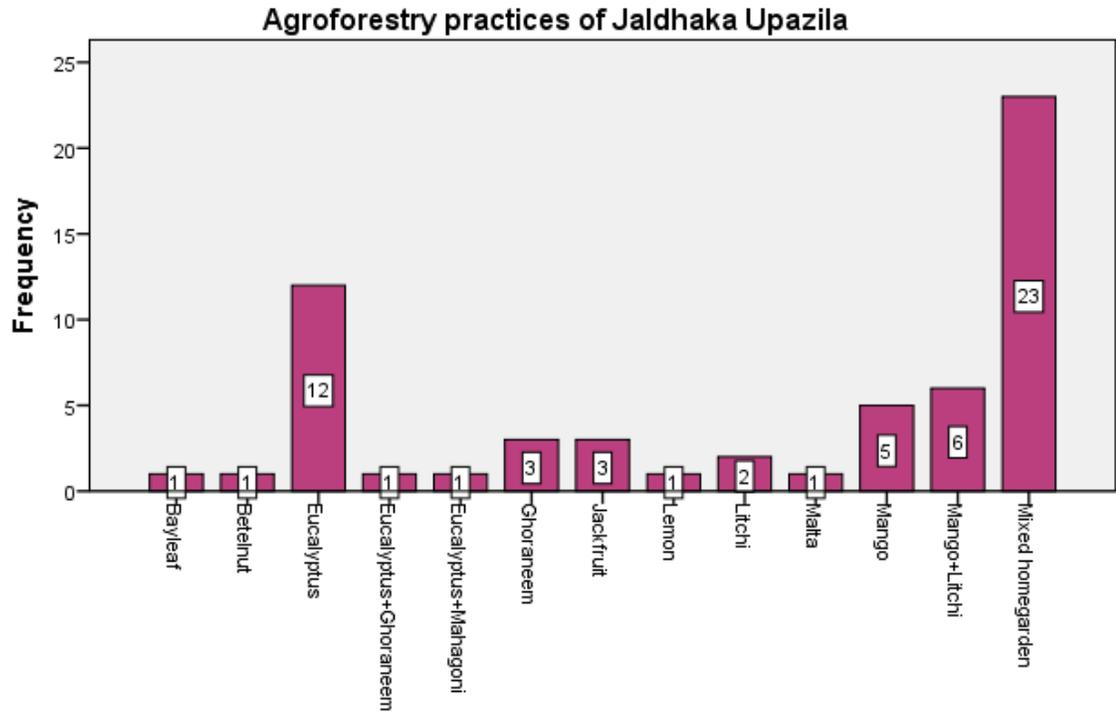


Figure 27: Agroforestry practices of Jaldhaka upazila

### 11.3 Results of Panchbibi upazila

#### 11.3.1 Cost of agroforestry systems

Figure 28 shows the cost of homestead agroforestry of Panchbibi upazila under Joypurhat district. First year cost of homestead agroforestry was recorded Tk.1841 per ha. Gradually the cost was decreased. Second and third year costs were Tk.970 and 1010. Regression line shows the forecasted cost upto ten years. The trend line indicated the lowest cost of homestead after ten years (Tk 110 per ha). Here regression equation was obtained as  $y = -162x + 1497$

The equation shows the negative trend of cost in successive years. The value of  $R^2 = 0.822$  indicated the change of a year (here independent variable) changes the cost (dependent variable) to 82.2 %.

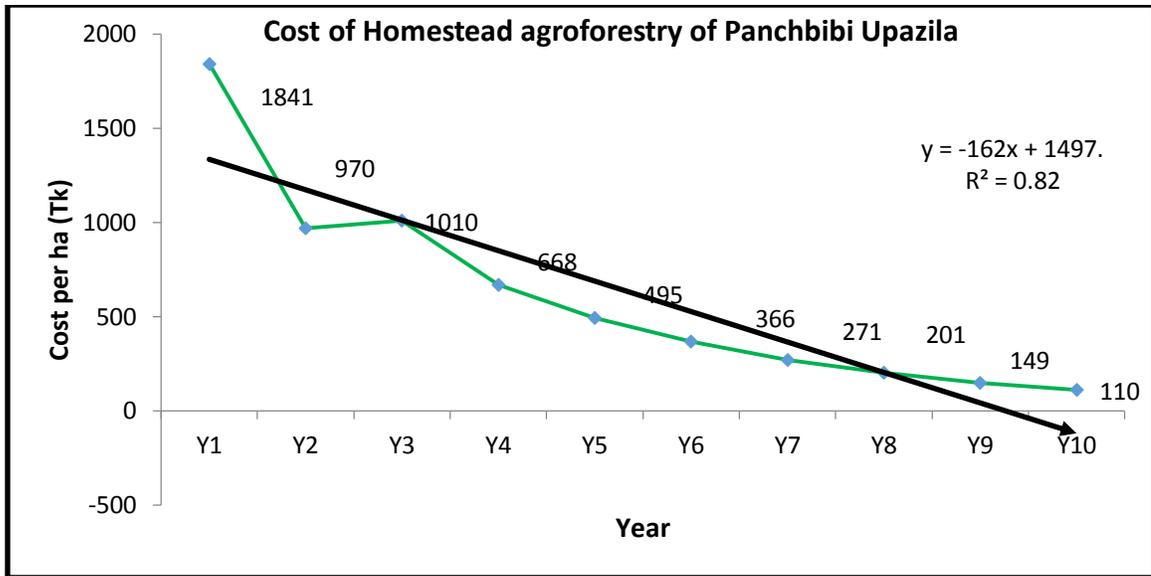


Figure 28: Cost of Homestead Agroforestry of Panchbibi Upazila

Figure 29 shows the cost of Orchard agroforestry of Panchbibi upazila under Joypurhat district. First year cost of Orchard agroforestry was recorded Tk.19137 per ha. Gradually the cost was decreased. Second and third year costs were 9099 and 10534. Regression line shows the forecasted cost upto ten years. The trend line indicated the lowest cost of orchard after ten years (Tk. 110 per ha). Here regression equation was obtained as  $Y = -1642x + 15196$

The equation shows the negative trend of cost in successive years. The value of  $R^2 = 0.796$  shows the change of a growing year (independent variable) changes the cost of growing orchard agroforestry (dependent variable) to 79.6%.

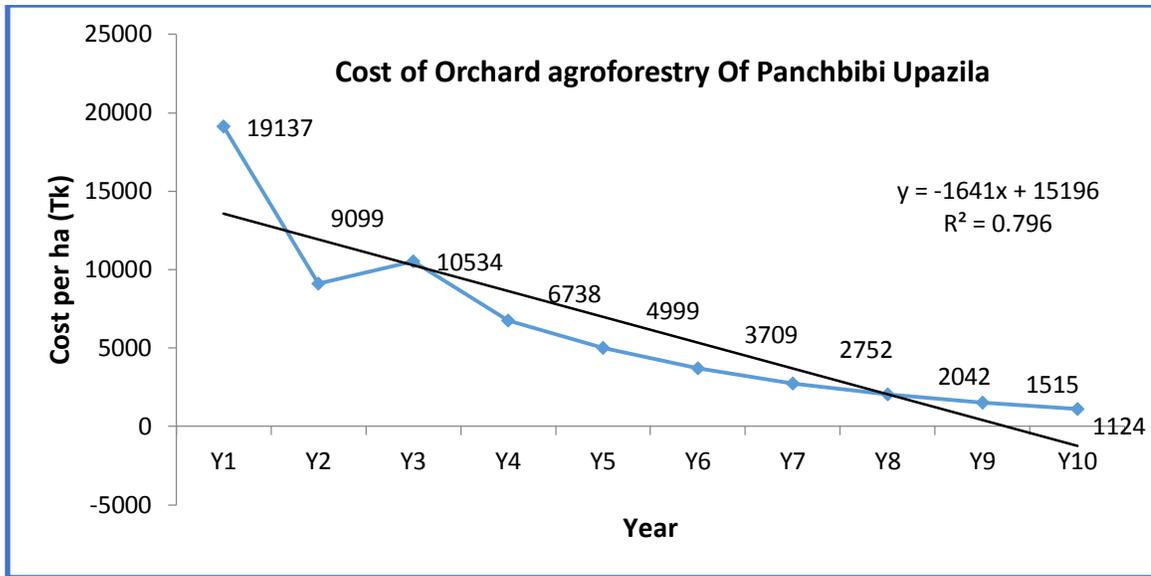


Figure 29: Cost of orchard agroforestry of Panchbibi Upazila Panchbibi Upazila

Figure 30 shows the cost of Cropland agroforestry of Panchbibi upazila. First year cost of cropland agroforestry was recorded tk12978per ha. Gradually cost was also decreased like homestead agroforestry. Second and third year costs were Tk. 10148 and Tk. 12849 per hectare. Regression line shows the forecasted cost upto ten years. The trend line indicated the lowest cost of orchard after ten years (Tk11449 per ha). The regression equation for cropland agroforestry of Panchbibi was obtained as  $Y = -68x + 12109$ . The equation shows the negative trend of cost in successive years. The value of  $R^2 = 0.07$  indicated the change of 1 unit independent variable (here "year") changes the dependent variable (here cost) 7%.

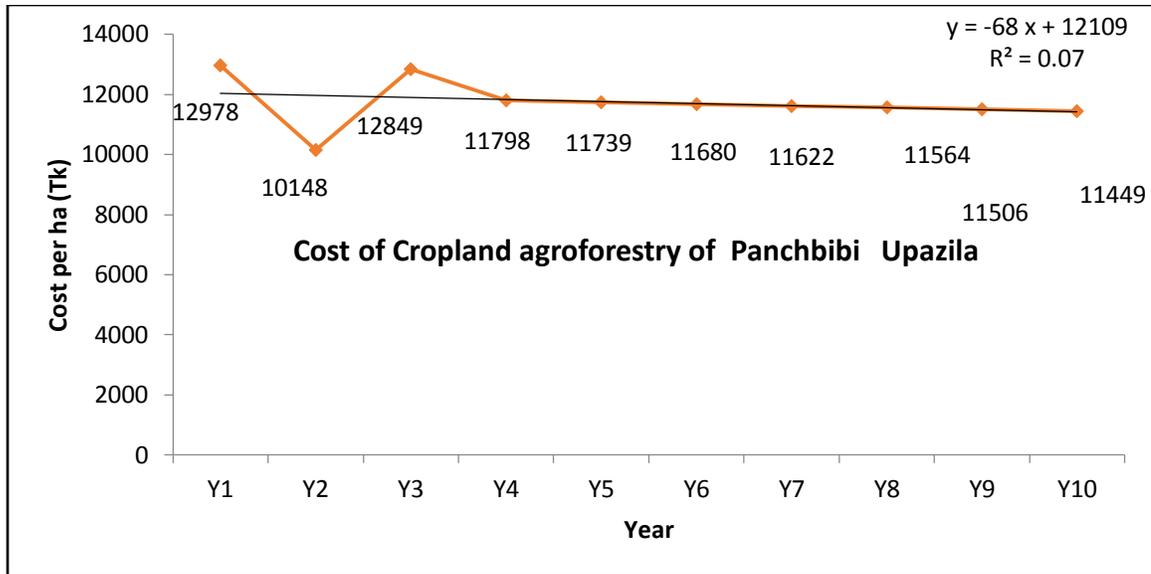


Figure 30 Cost of Cropland Agroforestry of Panchbibi upazila

### 11.3. 2 Income of agroforestry systems

The income from the agroforestry system is an important indicator of how much money is acquired from a system. Figure 31 shows the income of homestead agroforestry of Panchbibi upazila under Joypurhat district. First year income of homestead agroforestry was recorded tk2273 per ha. Gradually the income was increased. Second and third year income were verywere2812 and 3461. Regression line shows the forecasted income upto ten years. The trend line indicated the highest income of homestead after ten years (Tk 15085 per ha). Here regression equation was obtained as  $Y= 1369x -546.1$ . It shows the Positive trend of income in successive years.

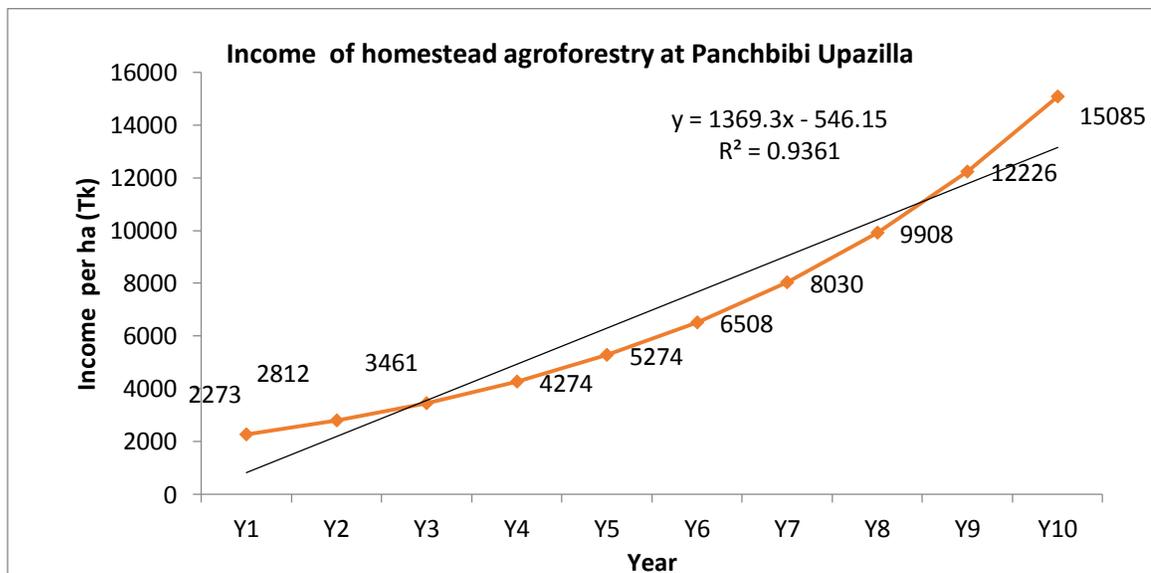


Figure 31: Income of Homestead Agroforestry of Panchbibi upazila

Figure 32 shows the income of Orchard agroforestry of Panchbibi upazila under Joypurhat district. First year income of Orchard agroforestry was recorded tk23437per ha. Gradually the cost was increased. The second year and third year income were 27227 and 33913. Regression line shows the forecasted cost upto ten years. The trend line indicated the highest income of orchard after ten years (Tk122152 per ha). Here regression equation was obtained as  $Y= 1067x +2316$ .

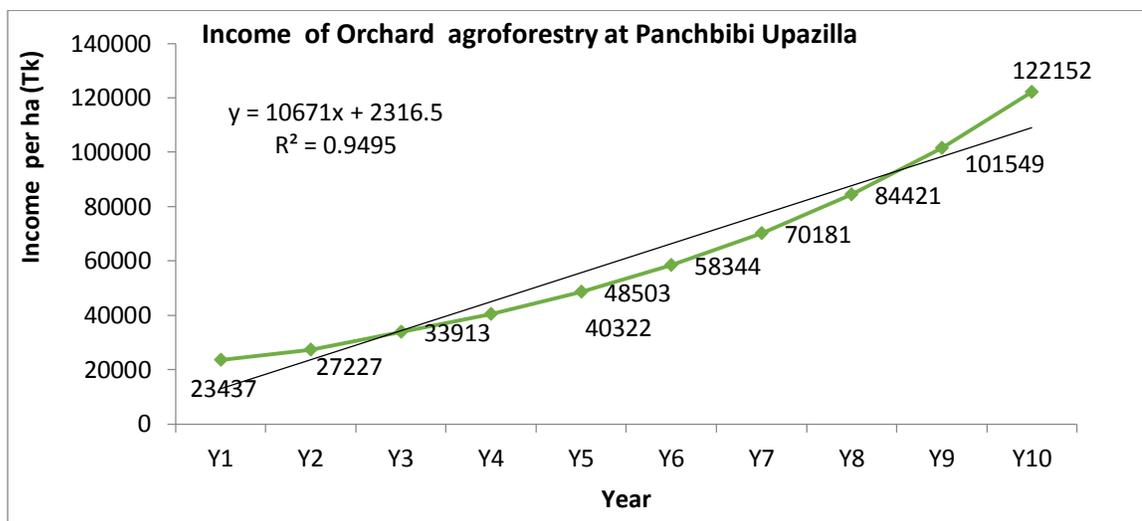


Figure 32: Income of orchard Agroforestry of Panchbibi upazila

Figure 33 shows the income of Cropland agroforestry of Panchbibi upazila under Joypurhat district. First year income of cropland agroforestry was recorded tk24847per ha. Gradually the income was decreased. Second and third year incomewere17370 and 18416 . Regression line shows the forecasted income upto ten years. The trend line indicated the lowest income of cropland after ten years (Tk6023per ha). Here regression equation was obtained as  $Y= -1889x + 23348$

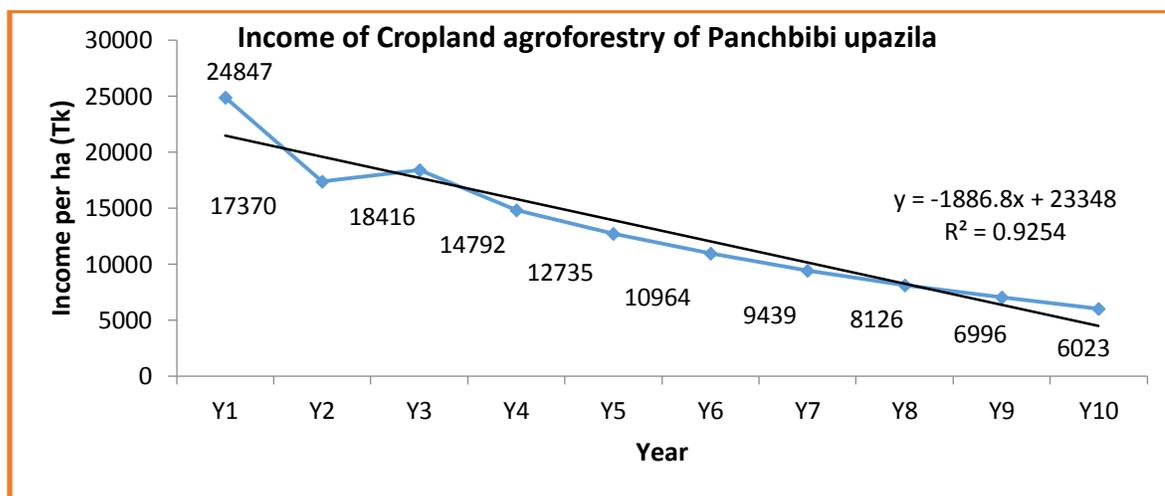


Figure33: Income of cropland agroforestry of Panchbibi upazila

### 11.3. 3 Income of agroforestry practices

Figure 34 presents three years income of different agroforestry practices of Panchbibi Upazila. In the first year, highest income was recorded in eucalyptus + mahogany based agroforestry practice followed by, mango, eucalyptus + Akashmoni, mango + mahagoni, litchi, mixed home garden, mango +litchi, eucalyptus, mahogany, jhingon + Jhiga, ghoraneem and the lowest income was found in eucalyptus+ Akashmoni practices. In second year, highest income was recorded in same agroforestry practice like 1st year and lowest income was recorded in mango + litchi based agroforestry practices. In third year, highest income was recorded in same as before two year practices and lowest income was recorded in mango + litchi based agroforestry practices.

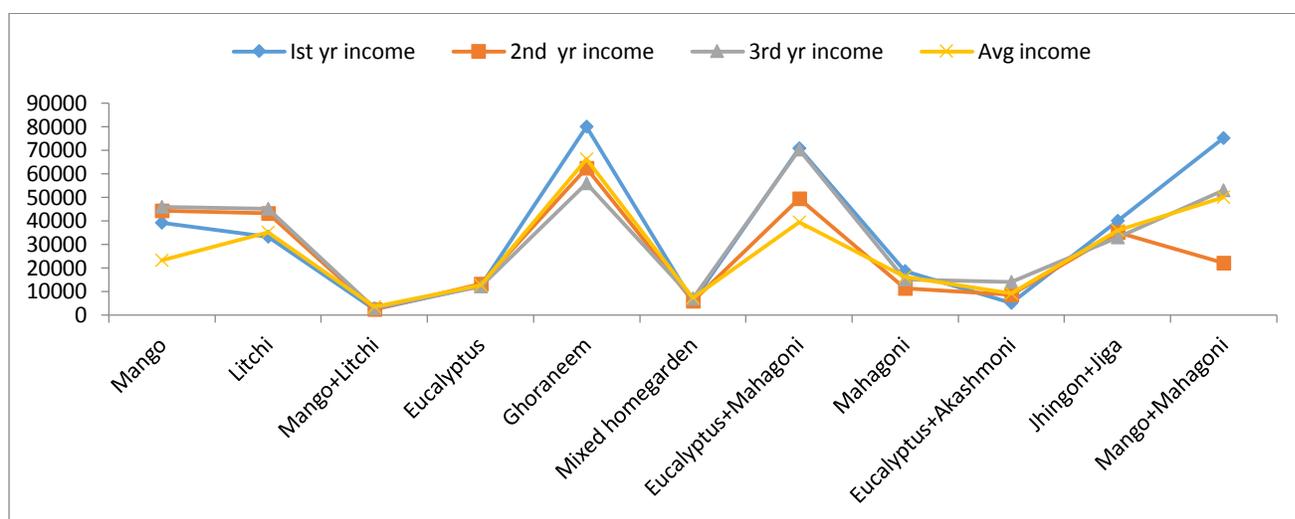


Figure 34: Gross income of different agroforestry practices of Panchbibi Upazila

### 11.3.4 BCR of Agroforestry systems

Figure 35 shows the BCR (Benefit Cost Ratio) of homestead agroforestry of Panchbibi upazila under Joypurhat district. First year BCR of homestead agroforestry was recorded 2.8 per ha. Gradually the benefit cost was increased. Second and third year benefit cost ratio were same. Regression line shows the forecasted BCR upto ten years. The trend line indicated the Highest of homestead after ten years (5.6 per ha). Here regression equation was obtained as  $Y = 0.302x + 2.413$ .

It shows the Positive trend of cost in successive years. The value of  $R^2 = 0.989$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here BCR) TO 0.989 or 98.9%.

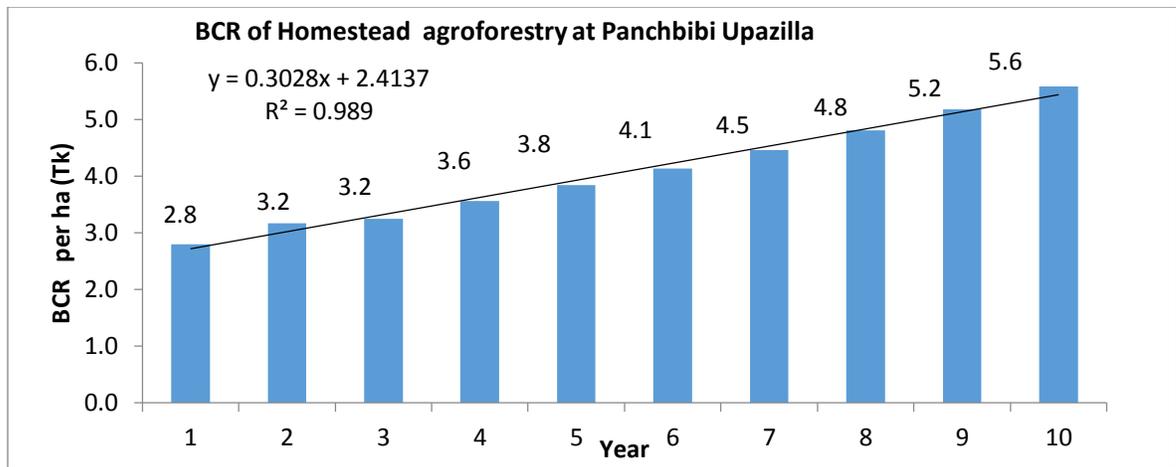


Figure 35: BCR (Benefit cost Ratio) of Homestead Agroforestry of Panchbibi Upazilla

Figure 36: shows the benefit cost ratio of Orchard agroforestry of Panchbibi upazila under Joypurhat district. First year BCR of Orchard agroforestry was recorded 2.8 per ha. Gradually the benefit cost ratio was increased. The second and third year benefit cost ratio were same. Regression line shows the forecasted BCR upto ten years. The trend line indicated the highest BCR of Orchard after ten years (4.5 per ha). Here regression equation was obtained as,  $y = 0.1901x + 2.5711$

The equation shows the positive trend of BCR in successive years. The value of  $R^2 = 0.9913$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here “BCR”) to 0.991 or 99.1%

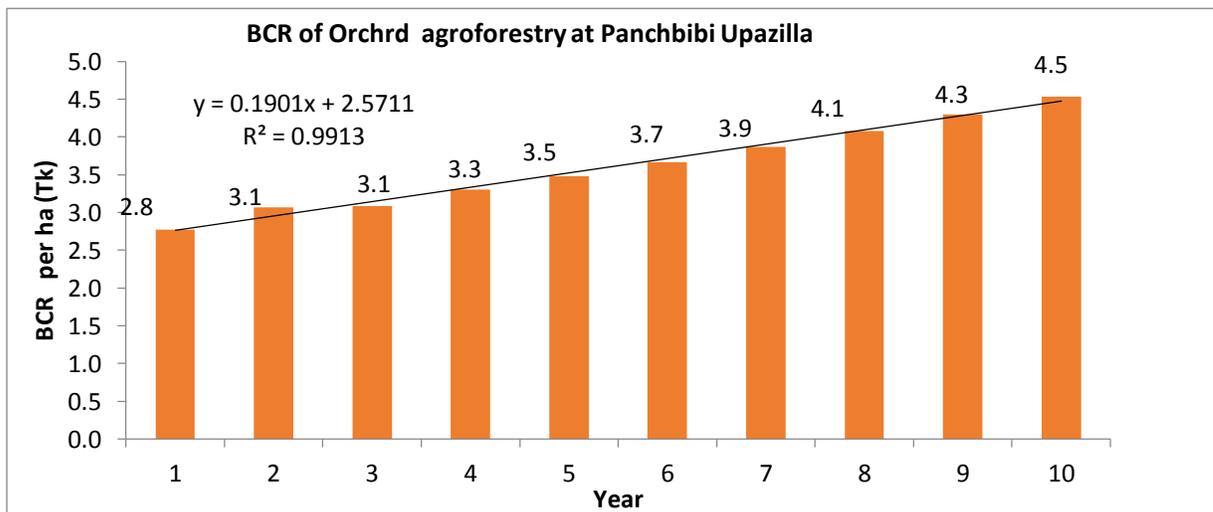


Figure 36: BCR of Orchard Agroforestry of Panchbibi upazila

Figure 37 shows the BCR of Crop land agroforestry of Panchbibi upazila under Joypurhat district. First year BCR of Crop land agroforestry was recorded 2.9 per ha. Gradually the income was decreased. Second year ratio was

same as first year ratio. Regression line shows the forecasted BCR upto ten years. The trend line indicated the lowest BCR of Crop land after ten years (2.5 per ha). Here regression equation was obtained as  $Y = -0.042x + 2.954$

The above equation shows the negative trend of BCR in successive years. The value of  $R^2 = 0.998$  indicated the change of 1 unit independent variable (here "year") changes the dependent variable (here BCR) TO 0.998 or 9.98%

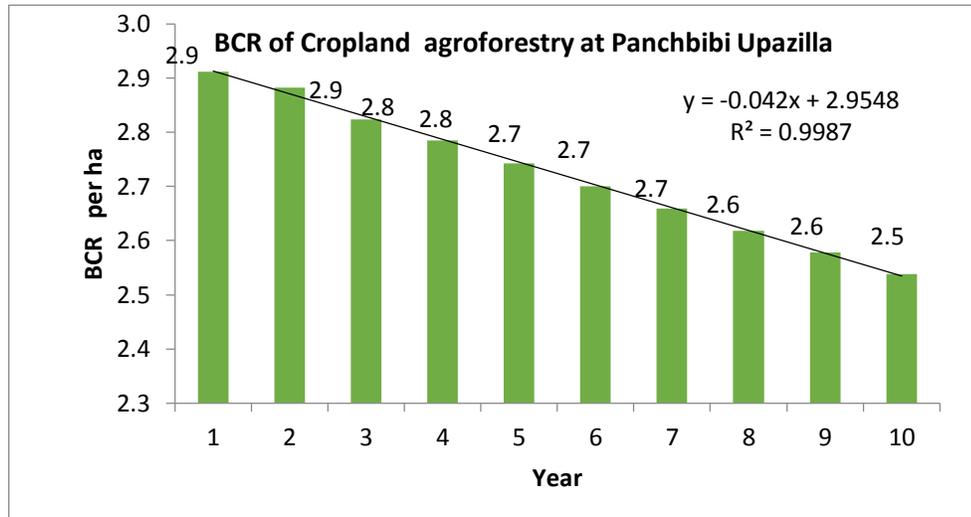


Figure 37: BCR of Cropland Agroforestry of Panchbibi upazila

#### 11.4.5 Net Income of agroforestry systems

The net income of the cropland agroforestry grower is an important indicator of how much they get profit from their farm practice. Figure 38 shows the net income of homestead agroforestry of Panchbibi upazila under Joypurhat district. First year net income of homestead agroforestry was recorded tk1 per ha. Gradually the net income was increased. Second and third year net income was same. Regression line shows the forecasted net income upto ten years. The trend line indicated the highest net income of homestead after ten years (Tk 137 per ha). Here regression equation was obtained as  $Y = 12.6x - 35.30$

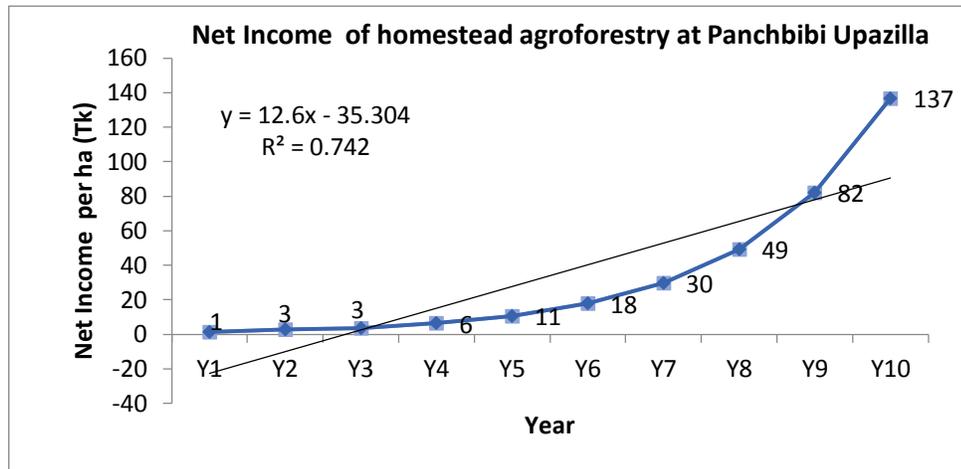


Figure 38: Net income of Homestead Agroforestry of Panchbibi Upazilla

Figure 39 shows the net income of Orchard agroforestry of Panchbibi upazila under Joypurhat district. First year income of orchard agroforestry was recorded tk .1per ha. Gradually the net income was increased. The second and third year net income were 2and 3. Regression line shows the forecasted net income upto ten years. The trend line indicated the highest net income of orchard after ten years (Tk .109 per ha). Here regression equation was obtained as  $Y= 10.14x -27.59$

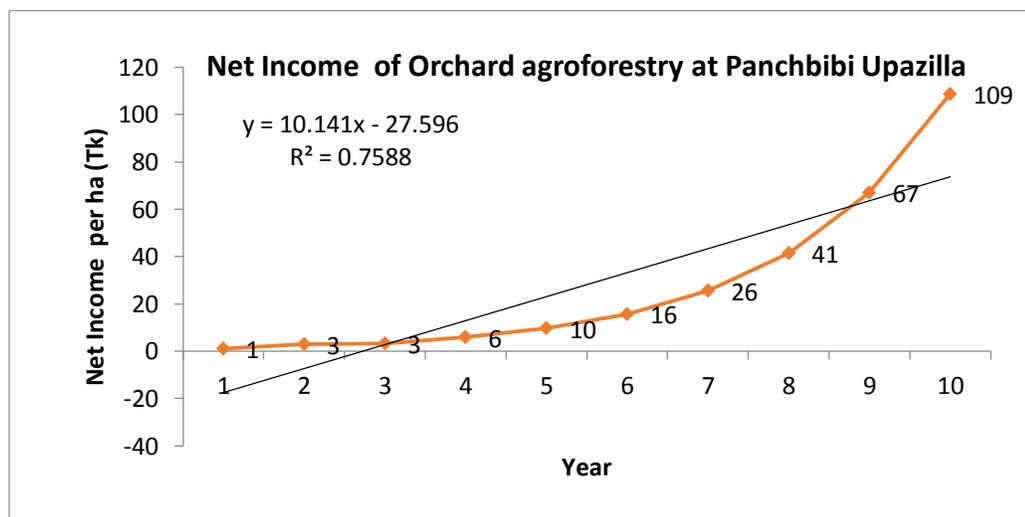


Figure 39 :Net income of Orchard Agroforestry of Panchbibi Upazilla

Figure 40 shows the net income of Cropland agroforestry of Panchbibi upazila under Joypurhat district. First year net income of cropland agroforestry was recorded Tk 2 per ha. Gradually the net income was decreased. After Second year all the net incomes were same. Regression line shows the forecasted income upto ten years. The trend line indicated the lowest income of cropland after ten years (1 per ha). Here regression equation was

obtained as  $Y = -0.154x + 1.945$ , It shows the negative trend of income in successive years. The value of  $R^2 = 0.967$  indicated the change of 1 unit independent variable (here "year") changes the dependent variable (here net income) to 0.967 or 9.67 %

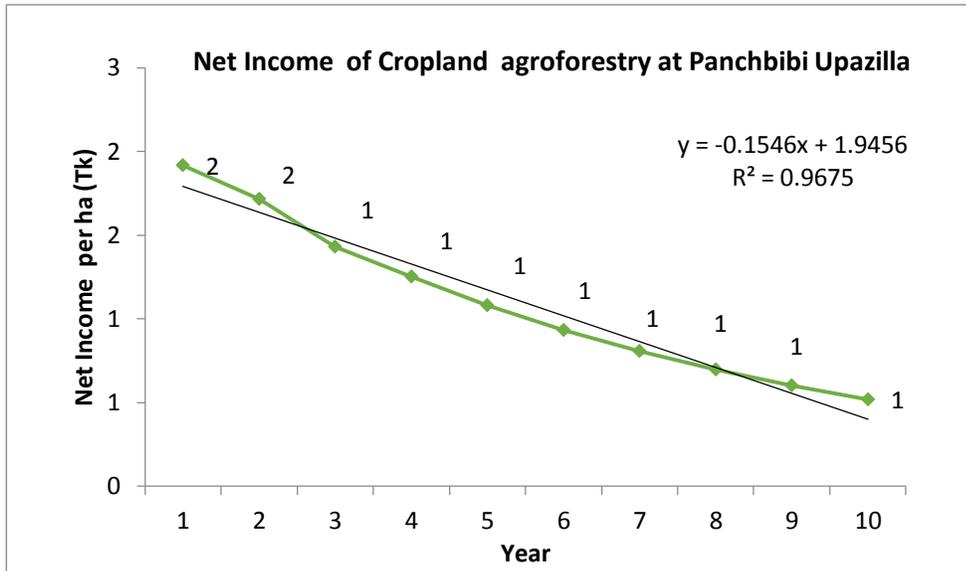


Figure 40: Net Income of Cropland Agroforestry of Panchbibi upazila

### 11.3.6 Identification of agroforestry practices

Different types of agroforestry practices were observed in Panchbibi upazila. Figure 41 presents different agroforestry practices of Panchbibi upazila, Joypurhat. Among 57agroforestry practices Mixed home garden occupied the highest number(29) followed by Eucalyptus(7),Mango(5), Mahagoni (5), Eucalyptus + Akashmoni (3), Eucalyptus + Mahogany (2) Litchi (2)and lowest number(1) was Mango+ Litchi, Mango+ Mahagoni, Jhington+Jhiga, Ghoraneem

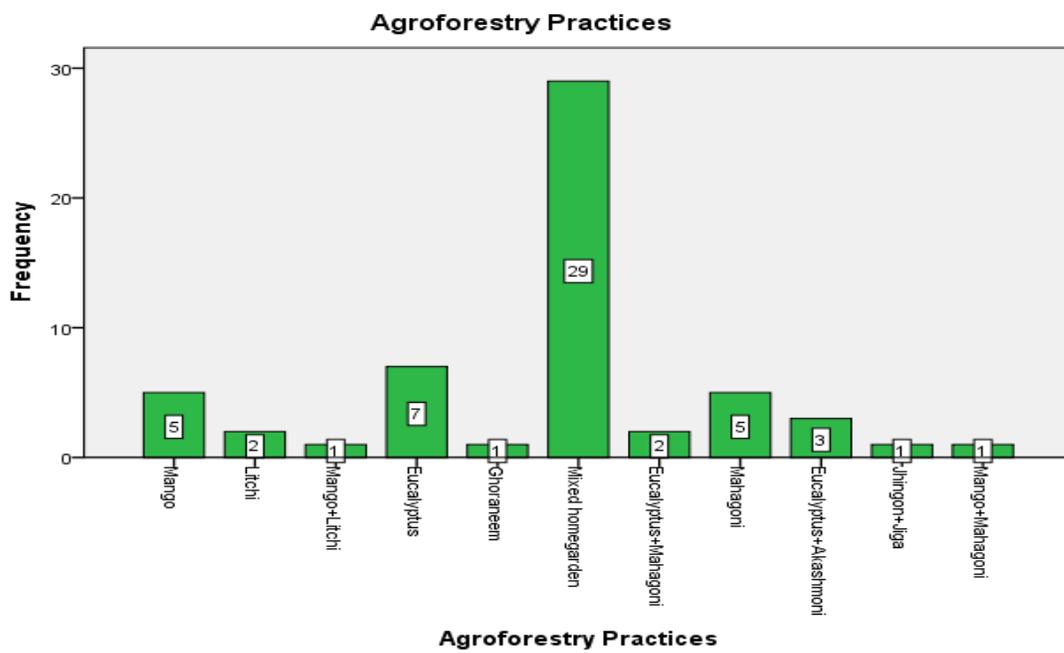


Figure 41: Agroforestry Practices of Panchbibi Upazila

### 11.3.7 Photo plates of Panchbibi upazila



Plate9 :Data collection using questionnaire



Plate 10.Orchard of Mango +Turmeric



Plate 11.Mahogany + Eucalyptus based agroforestry



Plate 12. Cropland of Bitter gourd +Eucalyptus

Plate 9-12: Different agroforestry practices of Panchbibi upazila of Joypurhat district

### 11.4 Results of Gurudaspur upazila

Cost of agroforestry of Gurudaspur upazila was analyzed by the collection of three years data with the help of the agroforestry growers. Based on the collected data, seven years costs were forecasted with the help of a regression equation.

#### 11.4.1 Cost of agroforestry systems

Figure 42 shows the cost of homestead agro forestry of GurudaspurUpazila under Natore district. First year cost of homestead agro forestry was recorded Tk. 56265 per ha. The cost was decreased in second year (TK.42430per ha) but increased in third year (TK.45574 per ha ). Regression line shows the forecasted cost up to ten years. The trend line indicated the lowest cost of homestead after ten years (Tk. 20549per ha). The regression equation was obtained as  $y = -3603x + 54419$

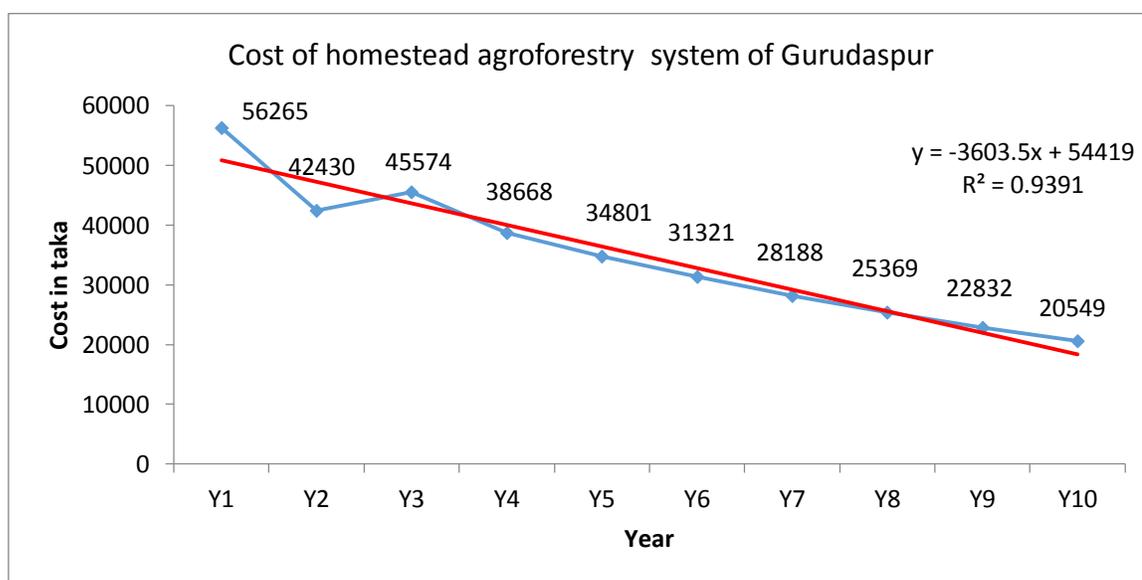


Figure 42: Cost of homestead agro forestry of Gurudaspur upazila

Figure 43 presents the cost of cropland agro forestry of Gurudaspur upazila under Natore district. First year cost of homestead agro forestry was recorded Tk. 86477 per ha. The cost was decreased in second year (Tk. 71890 per ha) but increased in third year (Tk. 75357 per ha). Regression line shows the forecasted cost upto ten years. The trend line indicated the lowest cost of homestead after ten years (Tk. 47976 per ha). The regression equation was obtained as  $y = -4269x + 85761$

The above equation shows the negative trend of cost in successive years. The value of  $R^2 = 0.957$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here cost) to 0.957 or 95%.

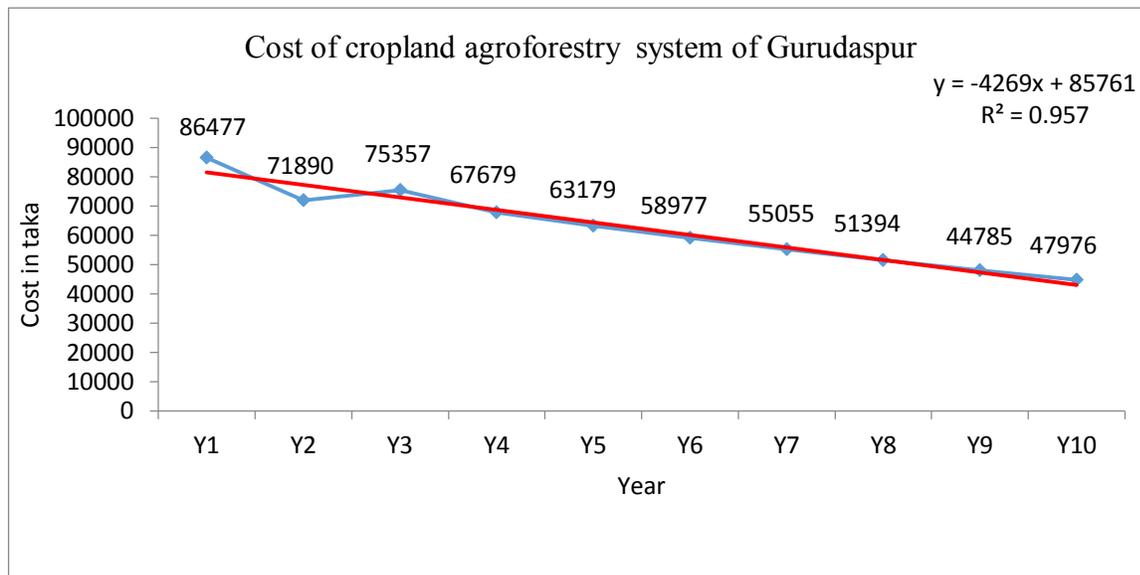


Figure 43: Cost of cropland agro forestry system of Gurudaspur upazila

Figure 44 shows the cost of orchard agro forestry of Gurudaspur upazila under Natore district. First year cost of orchard agro forestry was recorded Tk. 62523 per ha. The cost was decreased in second year (Tk. 53679 per ha) but increased in third year (TK. 55073 per ha). Regression line shows the forecasted cost up to ten years. The trend line indicated the lowest cost of homestead after ten years (Tk.34292 per ha). The regression equation for orchard agro forestry of Gurudaspur was derived as  $Y = -2931.x + 62524$

The Equation also shows the negative trend of cost in successive years like homestead and cropland agro forestry systems. The value of  $R^2 = 0.969$  indicated the change of 1 unit independent variable (here “year”) changes the dependent variable (here cost) to 0.957 or 96%.

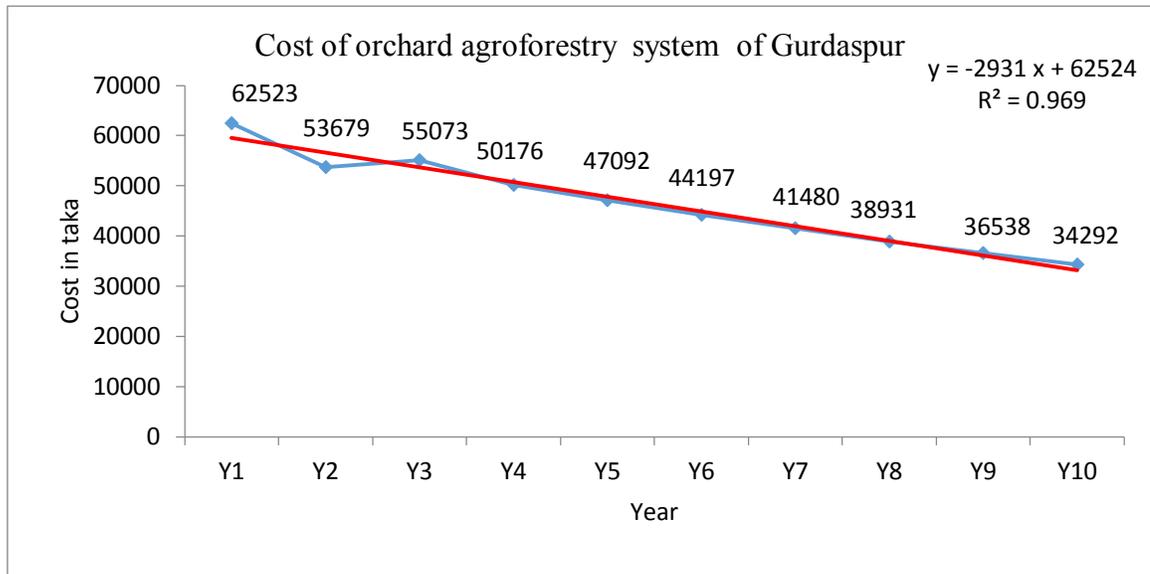


Figure 44: Cost of orchard agroforestry system of Guradaspur upazila

#### 11.4.2 Cost of agroforestry practices

Figure 45 presents the log transformed data of three years cost of different agroforestry practices of Guradaspur upazila. In the first year, highest cost was recorded in Mango + litchi based agroforestry practice followed by and the lowest cost was recorded in mixed home garden based agroforestry practices. Similar trend of cost was recorded in the second and third years for all the same practices. The figure also represents that highest cost was recorded in first year and lowest cost was recorded in third year.

From the above result it was clear that highest amount of cost was expended in first year in mango + litchi based agro forestry practices and lowest amount of cost was recorded in mixed home garden based practices.

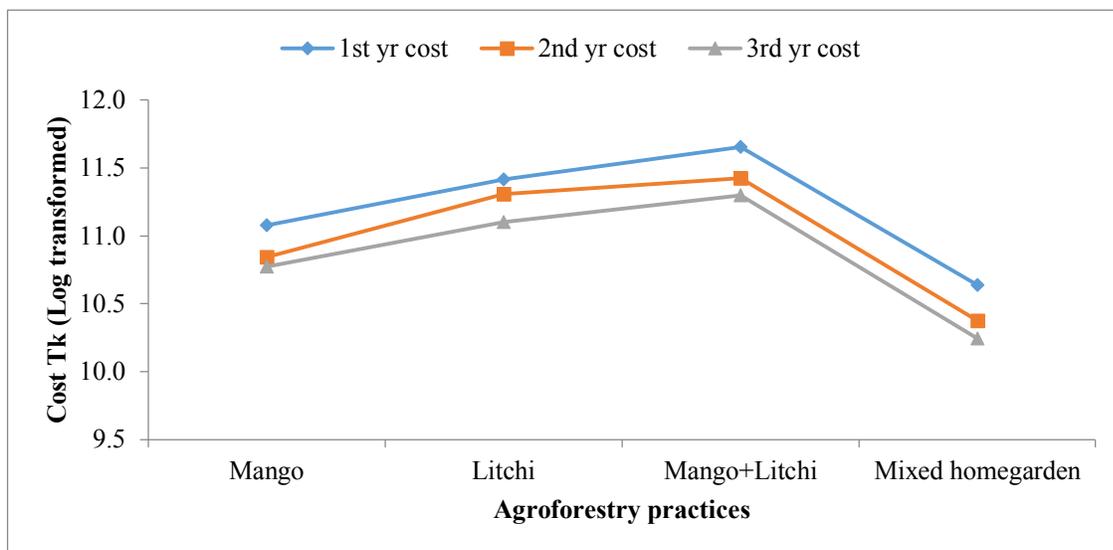


Figure 45: Cost of different agroforestry practices of Gurudaspur (Log transformed data)

### 11.4.3 Income of agroforestry systems

Figure 46 shows the income of homestead agro forestry of Gurudaspur upazila under Natore district. First year income of homestead agroforestry was recorded TK. 149314 per ha. Gradually the income was increased in successive years. Second year income was (TK.163595 per ha) and in third year income was (TK. 166157 per ha). Regression line shows the forecasted income up to ten years. The trend line indicated the highest income of homestead after ten years (Tk. 244606 per ha). The regression equation was obtained as  $Y=10344x + 13771$ . The equation shows the negative trend of cost in successive years. The value  $R^2= 0.992$  indicated the change of 1 unit independent variable (here "year") changes the dependent variable (here income) to 99%.

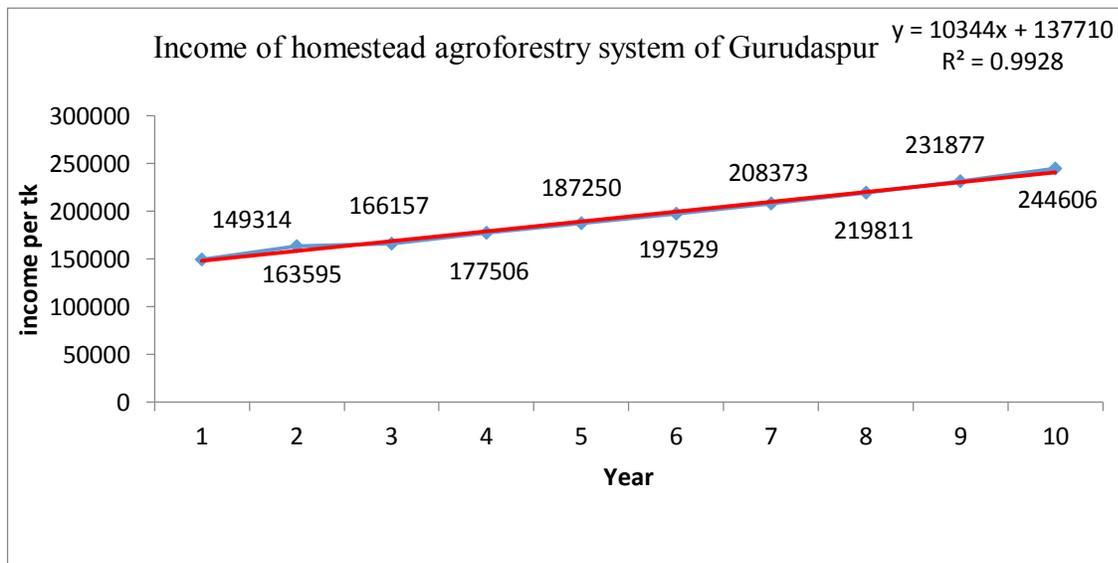


Figure 46: Income of homestead agroforestry system of Gurudaspur upazila

Figure 47 shows the income of cropland agro forestry of Gurudaspur upazila under Natore district. First year income of cropland agroforestry was recorded TK. 323340 per ha. Gradually the income was increased in successive years. Second year income was (TK. 270707 per ha) and in third year income was (Tk. 356379 per ha). Regression line shows the forecasted income upto ten years. The trend line indicated the highest income of homestead after ten years (Tk. 464552per ha). Here regression equation was obtained as,  $y=18065x + 27805$ . The Equation represents the negative trend of cost in successive years.

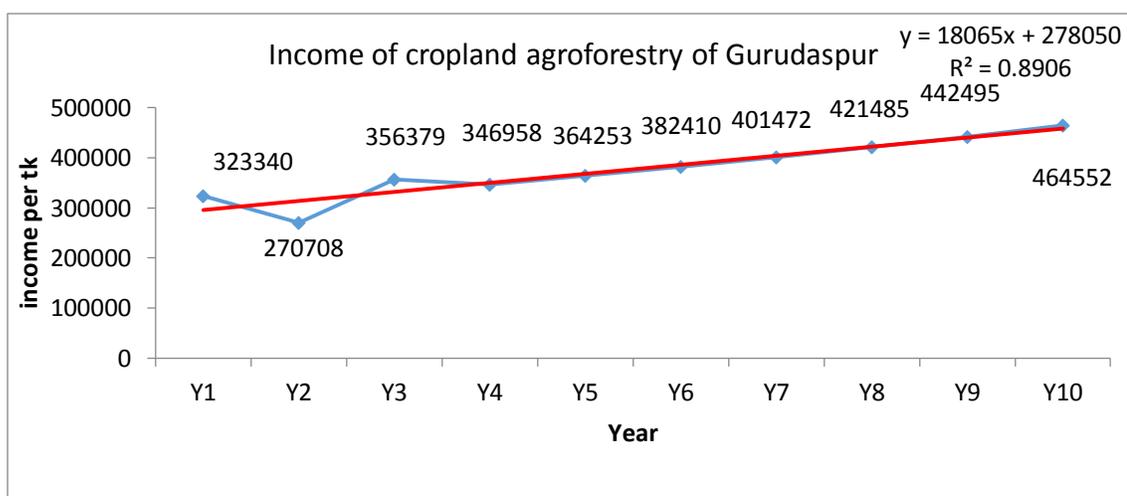


Figure 47: Income of cropland agroforestry system of Gurudaspur upazila

Figure 48 shows the income of orchard agro forestry of Gurudaspur upazila under Natore district. First year income of orchard agro forestry was recorded TK. 252048 per ha). Gradually the income was increased in successive years. Second year income was (TK. 289296 per ha) and in third year income was (TK. 290479 per ha). Regression line shows the forecasted income up to ten years. The trend line indicated the highest income of homestead after ten years (Tk. 488093 per ha). The regression equation was obtained as  $Y=25450x+22215$ . The equation shows the negative trend of cost in successive years. The value  $R^2= 0.987$  indicated the change of 1 unit independent variable changes the dependent variable 98%.

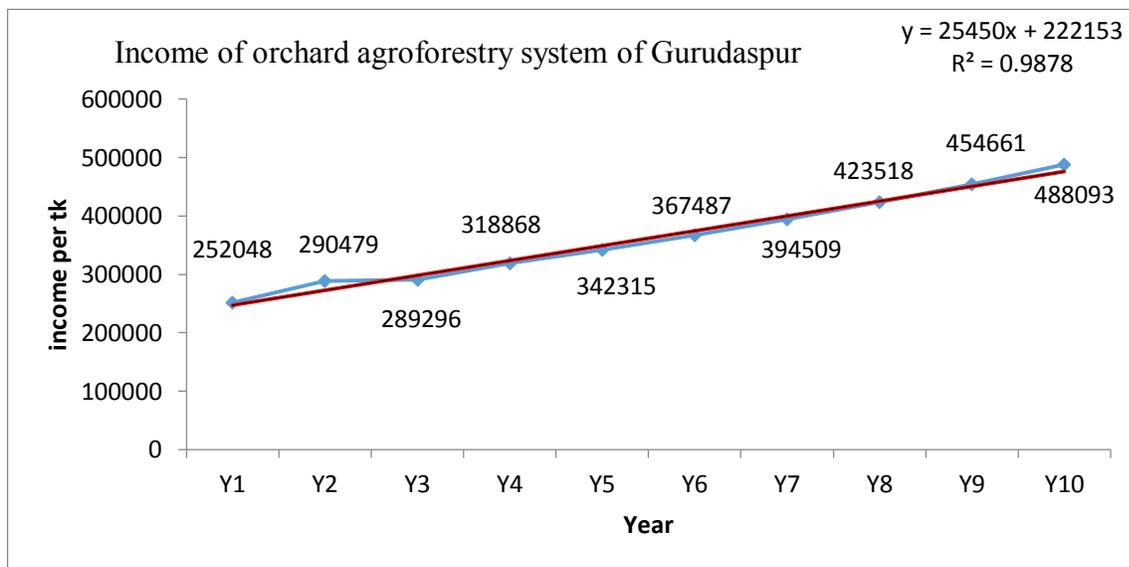


Fig 48: Income of orchard agroforestry system of Gurudaspur upazila

Figure 49 presents the log transformed data of three years income of different agroforestry practices of Gurudaspur upazila. In the first year, highest income was recorded in Mango + litchi based agroforestry practice followed by litchi, mango and the lowest BCR were found in mixed home garden based agroforestry practices. Similar result was found in the second and third years for the same practices. The figure also represents that highest income was recorded in third year and lowest net income was recorded in first year. From the figure we can see that highest income was recorded in third year in mango + litchi based agro forestry practices and lowest net income was recorded in first year in case of mixed home gardens.

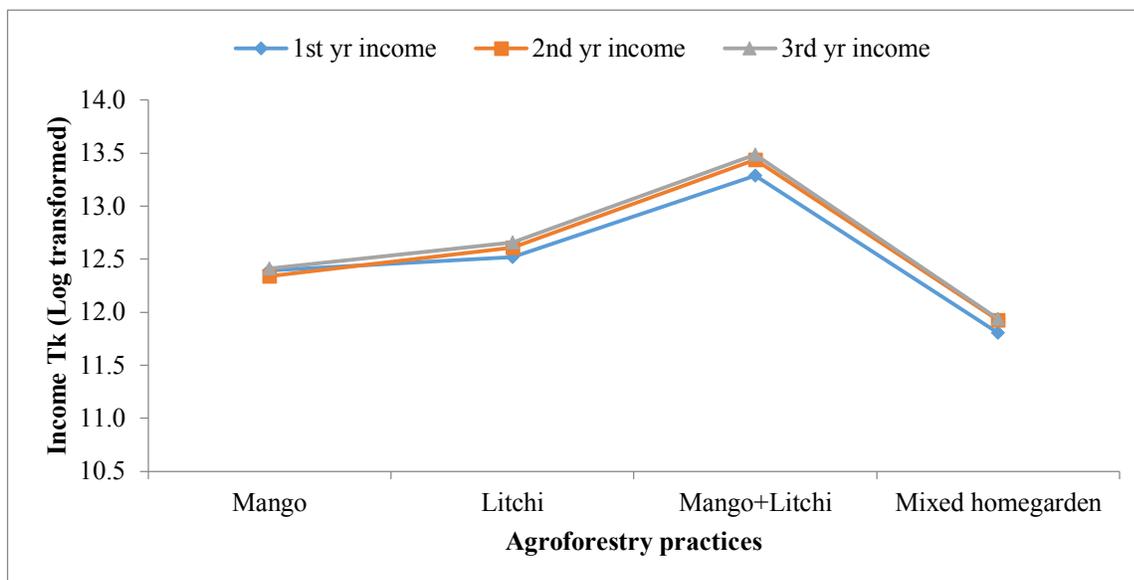


Figure 49: Income of different agroforestry practices of Gurudaspur upazila (Log transformed data)

#### 11.4.4 Net income of agroforestry systems

Figure 50 shows the net income of homestead agroforestry of Gurudaspur upazila under Natore district. First year net income of homestead agro forestry was recorded Tk 93049per ha). In second year net income was increased (Tk. 121165 per ha) but in third year net income was decreased a little (Tk. 120583 per ha). But net income was increased after three years in successive years. Regression line shows the forecasted net income up to ten years. The trend line indicated the highest net income of homestead after ten years (Tk. 224057 per ha). Here regression equation was obtained as:  $y=13947x + 83291$  The equation shows the negative trend of cost in successive years. The value,  $R^2= 0.991$  indicated the change of 1 year changes the income to 99.1 %.

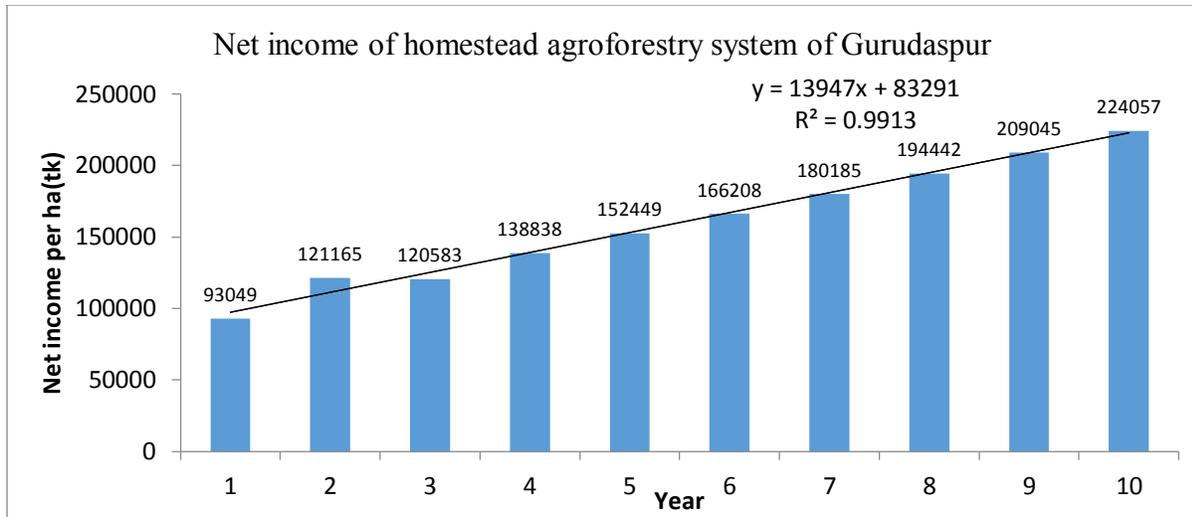


Fig 50: Net income of homestead agroforestry system of Gurudaspur upazila.

Figure 51 shows the net income of cropland agroforestry of Gurudaspur upazila under Natore district. First year net income of cropland agroforestry was recorded Tk.236863per ha). In second year net income was decreased Tk. 198817 per ha but in third year net income was increased a little (Tk. 281021per ha). But net income was increased after two years in successive years. Regression line shows the forecasted net income up to ten years. The trend line indicated the highest net income of cropland after ten years (Tk. 419766 per ha). Here regression equation was obtained as:  $y=22334x + 19228$ . The equation shows the negative trend of cost in successive years. The value  $R^2= 0.943$  indicated the change of 1 year, changes the dependent variable-net income to 94%.

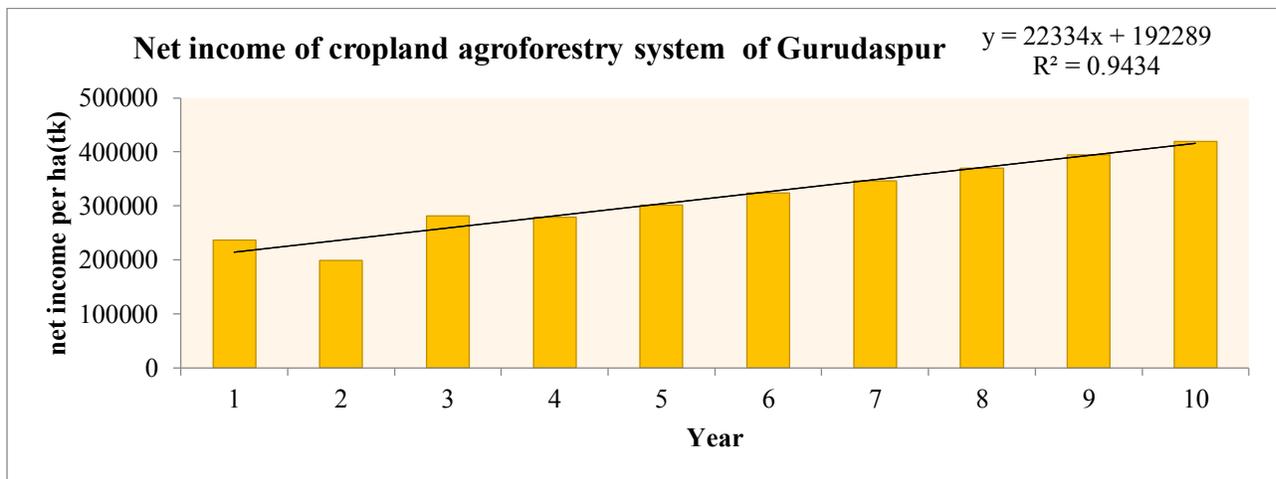


Fig 51: Net income of cropland agro forestry system of Gurudaspur upazila

Figure 52 shows the net income of orchard agro forestry of Gurudaspur upazila under Natore district. First year net income of orchard agroforestry was recorded Tk 189525per ha). In second year net income was increased Tk. 235616 per ha but in third year net income was decreased a little (Tk. 235405per ha). But net income was increased after three years in successive years. Regression line shows the forecasted net income up to ten years. The trend line indicated the highest net income of homestead after ten years (Tk. 453800per ha). Here regression equation was obtained as:  $y = 28382x + 15962$ .

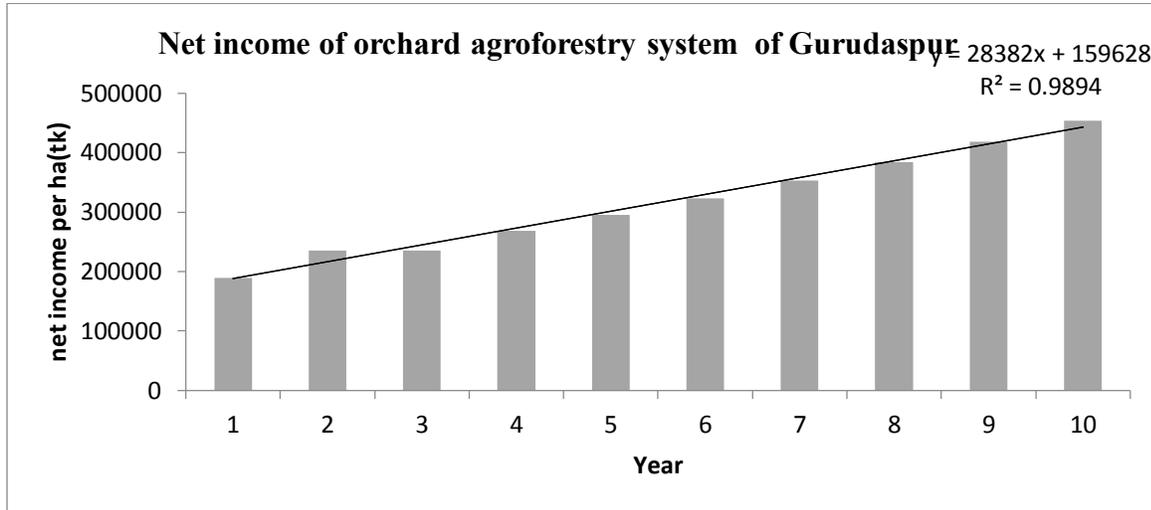


Fig. 52: Net income of orchard agro forestry system of Gurudaspur upazila

#### 11.4.5 Net income of agroforestry practices

Figure 53 represents the log transformed data of three years net income of different agroforestry practices of Gurudaspur upazila. In the first year, highest net income was recorded in Mango + litchi based agroforestry practice sand the lowest BCR was found in mixed home garden based agroforestry practices. Similar result was recorded in the second and third year for the same practices. The figure also represents that highest net income was recorded in third year and lowest net income was recorded in first year.

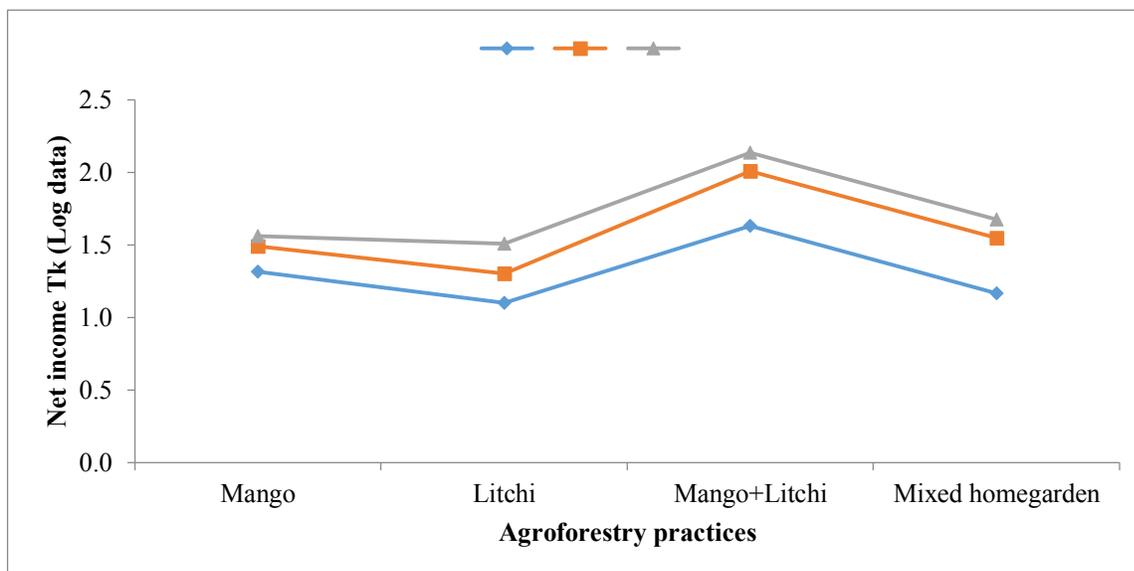


Fig. 53: Net income of different agroforestry practices of Gurudaspur (LN data)

#### 11.4.6 BCR of agroforestry systems

Figure 54 shows the benefit cost ratio of homestead agroforestry of Gurudaspur upazila under Natore district. First year benefit cost ratio of homestead agroforestry was recorded 2.65 per ha). In second year benefit cost ratio was increased in 3.86 per ha but in third year benefit cost ratio was decreased a little (3.65 per ha). But benefit cost ratio was increased after three years in successive years. Regression line shows the forecasted benefit cost ratio upto ten years. The trend line indicated the highest benefit cost ratio of homestead after ten years 11.90. Here regression equation was obtained as:  $y = 0.980x + 1.062$ . The equation shows the negative trend of cost in successive years. The value of  $R^2 = 0.956$  indicated the change of 1 unit independent variable (here "year") changes the dependent variable (here benefit cost ratio) to 0.956 or 95 %.

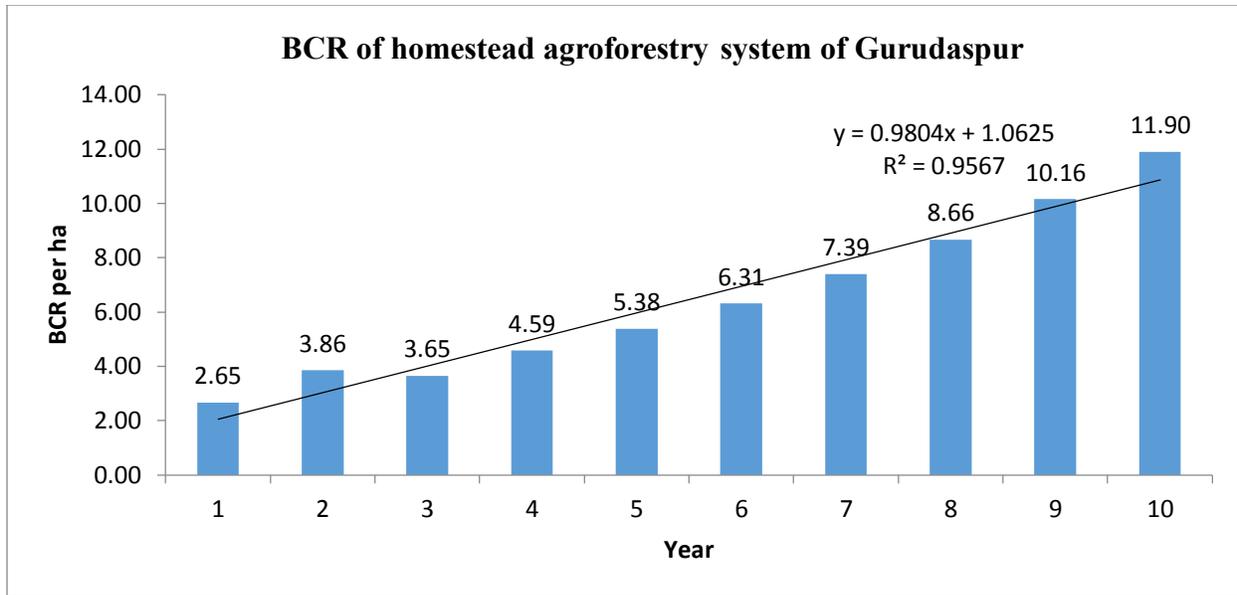


Figure 54: Benefit cost ratio of homestead agroforestry system of Gurudaspur upazila

Figure 55 shows the benefit cost ratio of cropland agroforestry of Gurudaspur upazila under Natore district. First year benefit cost ratio of cropland agroforestry was recorded 3.74 per ha). Gradually it was increased in successive years. In second year benefit cost ratio was recorded in 3.77 per ha and in third year benefit cost ratio was 4.73 per ha). Regression line shows the forecasted benefit cost ratio up to ten years. The trend line indicated the highest benefit cost ratio of homestead after ten years (10.37 per ha). Here regression equation was obtained as:  $y = 0.742x + 2.387$ . The equation shows the negative trend of cost in successive years. The value  $R^2 = 0.975$  indicated the change of 1 unit independent variable (here "year") changes the dependent variable (here benefit cost ratio) to 97 %.

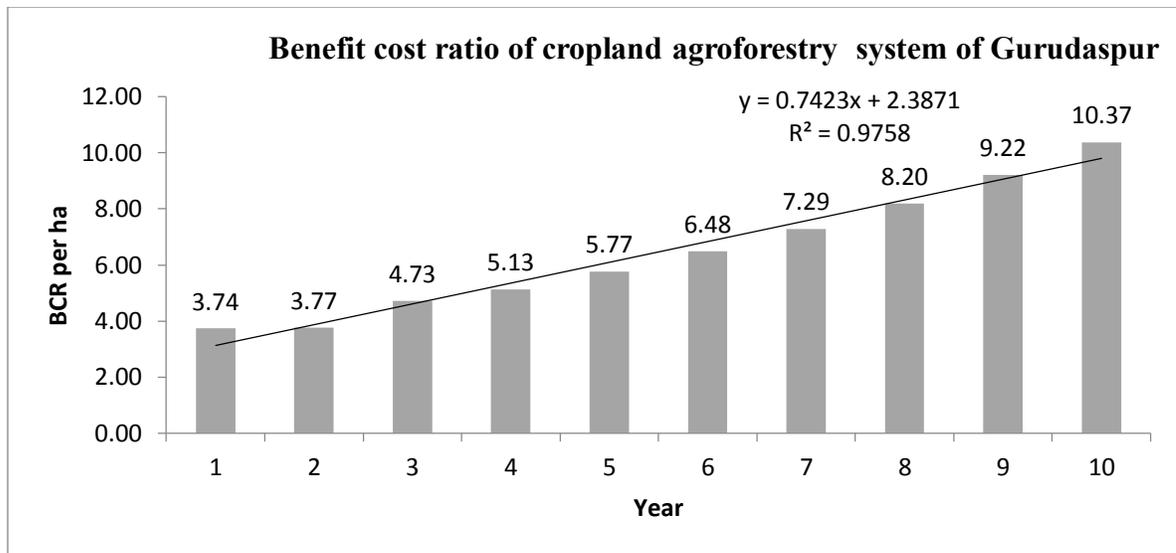


Figure 55: Benefit cost ratio of cropland agroforestry system of Gurudaspur upazila

Figure 56 shows the benefit cost ratio of orchard agroforestry system of Gurudaspur upazila under Natore district. First year benefit cost ratio of orchard agroforestry was recorded(4.03 per ha). It was increased in second year (5.39 per ha) but decreased in third year (5.27 per ha). After third year it was increased in successive years. Regression line shows the forecasted benefit cost ratio upto ten years. The trend line indicated the highest benefit cost ratio of orchard after ten years (14.23per ha). The regression equation was obtained as:  $Y=1.089x + 2.378$ .

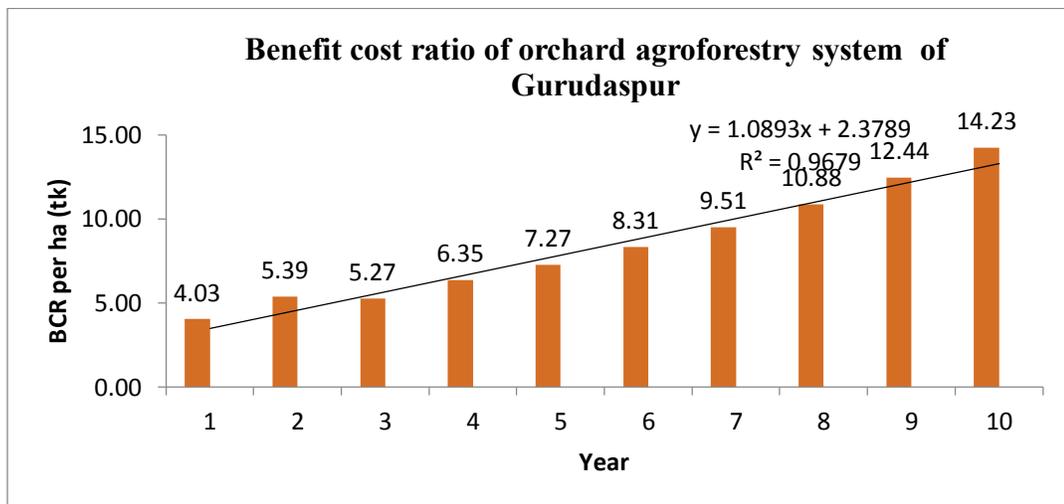


Figure 56: Benefit cost ratio of orchard agroforestry system of Gurudaspur upazila

### 11.4.7 BCR of agroforestry practices

Figure 57 presents log transformed data of three years BCR of different agroforestry practices of Gurudaspur upazila. In the first year, highest BCR was recorded in Mango + litchi based agroforestry practice and the lowest BCR was found in mixed home garden based agroforestry practices. In the second year, highest BCR was found in mixed home garden based agroforestry practices. In the second year, highest BCR was recorded in Mango + litchi based agroforestry practice and the lowest BCR was found in mixed home garden based agroforestry practices and similar result was found in the third year. The figure also represents that highest BCR was recorded in third year and lowest BCR was recorded in first year.

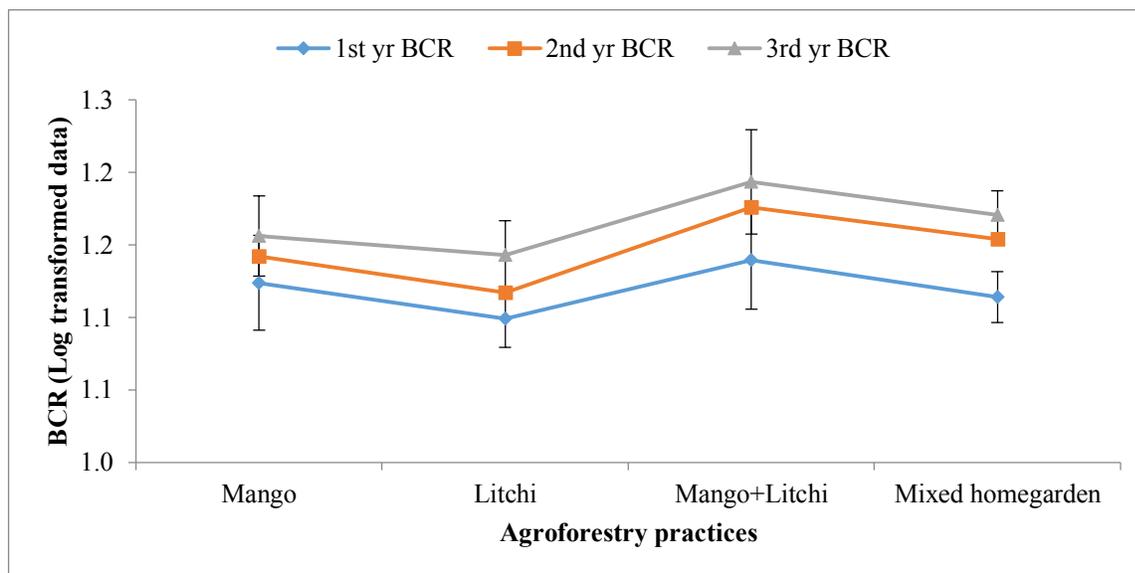


Figure 57 : Benefit cost ratio of different agro forestry practices of Gurudaspur, Natore district (Log transformed data)

### 11.4.8 Identification of agroforestry practices

Figure 58 shows that cross tabulation of different agro forestry practices of Gurudaspur upazila of Natore district. In homestead agroforestry systems maximum number 8 was recorded in mixed home garden followed by 5 in both mango and litchi agroforestry practices but minimum number 2 was recorded in mango + litchi practices. In case of cropland agroforestry systems maximum number 7 was recorded in both litchi and mixed home garden agroforestry practices followed by 4 in mango agroforestry practices but minimum number 2 was recorded in mango + litchi.. In case of orchard agroforestry systems maximum number 10 was recorded in mixed home garden agroforestry practices followed by 3 in mango agroforestry practices and 6 was recorded in litchi

practices but minimum number 1 was recorded in mango + litchi. Total number of practices was recorded 25 in mixed home garden, 5 in mango+ litchi based, 18 in litchi based and 12 in mango based agroforestry practices.

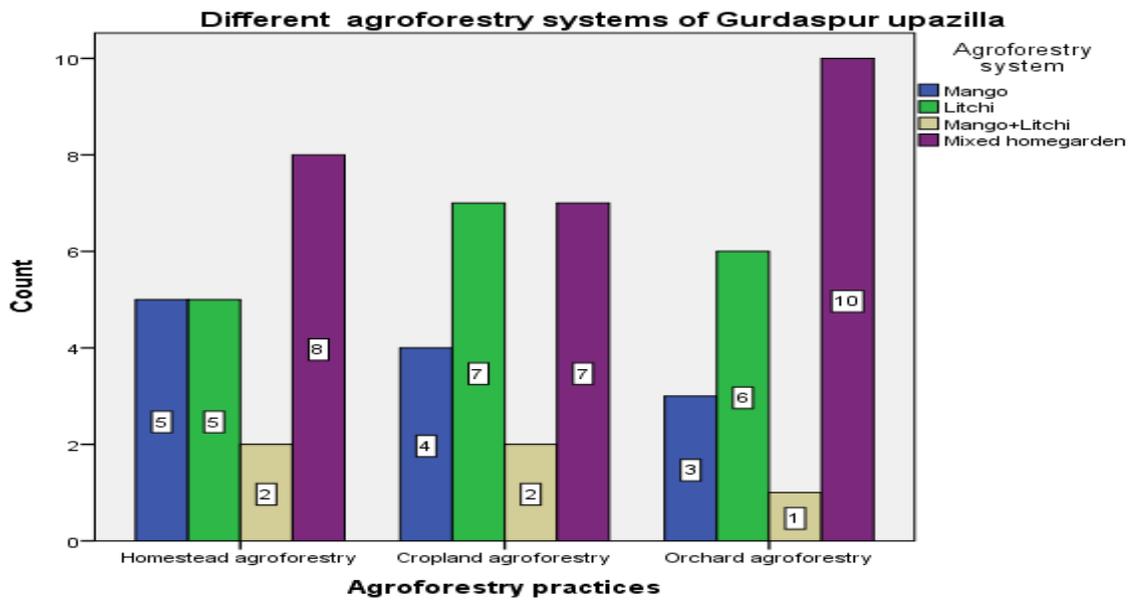


Figure 58: Different agroforestry practices of Gurudaspur upazilla of Natore district.

#### 11.4.9 Photo plates of Gurudaspur upazila



Plate 13. Turmeric + litchi based cropland agroforestry



Plate 14: Data collections at homesteads



Plate 15: Data collection at homestead



Plate 16: Data collection of litchi based orchard

Plate 13-16: Agroforestry practices of Gurudaspur upazila of Natore district

### 11.5 Discussion on the results

Comparing the initial costs of three agroforestry systems, highest cost was recorded in orchard agroforestry followed by cropland agroforestry and lowest cost was recorded in homestead agroforestry system. This is because in orchard agroforestry, intensive care is needed. In first year there were seedling costs, land preparation cost, fencing cost, labor cost, fertilizer cost, pesticide cost etc. The same costs were less in cropland and homestead agroforestry systems because in cropland agroforestry, trees get benefits from the crop management and in homestead, family members take care of the trees and crops/ livestock without expensing additional cost. Cost decreased over time in all the systems because in the subsequent years, land preparation, fencing, labor, fertilizer, insecticide costs, etc were less compared to the same in the first year. 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. Price (1995) scrutinized the application of valuation techniques in estimating the costs and benefits associated with agroforestry systems. The study suggested that a systematic and quantitative investigation of all benefits and costs associated with agroforestry production is necessary to convince economists and landowners that agroforestry offers positive monetary and non-monetary benefits.

From the overall income of three agroforestry systems, it is seen that income of orchard agroforestry system is highest followed by cropland and homestead agroforestry systems. Although in the initial stages both crops and

trees were planted in orchards, cropland and homesteads, crop yield decreased and tree yield/ fruit yield increased over time. Having alternate bearing habit of fruit trees, third year income of orchard system had higher income than cropland and homestead agroforestry. The present study 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 agroforestry of southwestern Bangladesh and financial variability of shifting cultivation versus agroforestry project. Jorge *et al.* (1991) investigated the economic viability and technical feasibility of modern agroforestry practices in the Amazon. Their study determined that selected modern agroforestry practices (e.g. agrosilvicultural and silvopastoral) have the potential to increase wood and coffee production, improve labor efficiency, and reduce cash requirements during market lulls. Rathore *et al.* (2013) recorded higher yield in mango based orchard agroforestry system with different seasonal crops.

In case of homestead agroforestry practices first year benefit cost ratio that recorded increased in successive years. In case of cropland agroforestry practices first year benefit cost ratio was also increased in successive years. Benefit cost ratio was increased because in successive years cost was less than income. In case of orchard agroforestry practices first year benefit cost ratio was also increased in successive years. Benefit cost ratio was increased because in successive years cost was less than income. This result is in agreement with the result of Kibria and Shaha (2011) who obtained more BCR of agroforestry practices with pineapple in the Modhupur sal forest of Bangladesh while banana based system had more net present value. In spite of higher BCR of homestead agroforestry, farmers in the study area widely practiced the orchard agroforestry. It appears that the farmers' decision regarding what kind of land use they will adopt depends not on the BCR, but largely on the net amount of income that they earn (Cusworth and Franks, 1993; Thapa and Weber, 1994; Alam and Furukawa, 2008). Edward (1991) analyzed and compared the profitability of a wide variety of agroforestry practices in Senegal using NPV and Benefit/Cost ratio. The analyses were conducted from the farmer's viewpoint in an effort to bridge the information gap between agroforestry and landowners (Chouhan *et al.*, 2017). This study concluded that integration of agroforestry practices into traditional farming systems yields greater rates of return than monoculture practices alone.

## **12. Research highlight/findings**

Findings of the sub-project research are -

- In Kaharole upazila, nine categories of agroforestry practices were recorded based on the presence of perennial tree species out of 60 practices studied. Mixed home garden 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.

- In Jaldhaka upazila, within homestead, cropland and orchard agroforestry systems, 13 major categories of practices were identified out of 60 practices studied. The names with number of practices were mixed home garden (23), eucalyptus(12), mango+ litchi (6),mango(5), jackfruit (3), ghora neem (3) and number (1) were malta, lemon, eucalyptus + mahogoni, eucalyptus +ghora neem, betel nut, bay leaf based agroforestry systems.
- In Panchbibi upazila, 11 major categories of practices were identified out of 57 agroforestry practices studied. Mixed homegarden occupied the highest number (29) followed by eucalyptus (7), mango (5), mahogoni (5), eucalyptus +akashmoni (3), eucalyptus + mahogony (2), litchi (2) and lowest number (1) was mango+ litchi, mango+mahogoni, jhingon+betel leaf, ghoraneem.
- In Gurudaspur upazila, within homestead, cropland and orchard agroforestry systems, 4 major categories of practices were identified out of 60 practices studied. The names and numbers of practices were mango (12), mango +litchi (5), litchi (18) and mixed garden (25).
- The analysis of the data of four upazilas upazila showed that net income of orchard agroforestry system was higher than cropland and homestead agroforestry systems. Among the different categories of agroforestry practices, most profitable practices were varied in places, e.g. highest profitable practice was mango and guava in Kaharole upazila, betel nut was in Jaldhaka, mahogany + eucalyptus was in Panchbibi upazila and mango+ litchi was in Gurudaspur upazila.
- Successfully completed one- day long training for farmers and a workshop for policy makers and service providers on identification and economic analysis of improved agroforestry practices.
- Pictures of systems and practices were collected and four theses are prepared and documented in the Department of Agroforestry and Environment. These will be the source of further reference for the future prospective researchers.

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## B. Implementation Position

### 1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remark
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Laser printer, Digital camera, Desktop Computer, Scanner, UPS (Offline) Computer Chair, Steel Almira, Computer Table	157500	Laser printer, digital camera, desktop computer, scanner, ups (offline) computer chair, steel almira, computer table	157230	
(b) Lab & field equipment	Analytical Balance, Suntometer, Clinometers, Tree caliper Soil pH meter, Petri dish Measuring Cylinder Beaker, Conical flask Conical flask Acetone H <sub>2</sub> SO <sub>4</sub> , HCL	281800	analytical balance, suntometer, clinometers, tree caliper soil pH meter, petri dish measuring cylinder beaker, conical flask conical flask acetone H <sub>2</sub> SO <sub>4</sub> , HCL	279000	
(c) Other capital items	-	-	-	-	

## 2. Establishment/renovation facilities: N/A

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

## 3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) TrainingFarmers' Training on: "evsjv`†ki DËivÂ†j K...wl ebvqb cÖhyw <sup>3</sup> Dbæq†bi Rb" we`gvb K...wl ebvqb Pvl c×wZ wPwýZKiY Ges A_©%obwZK we†kølbÓ	19	01	20	01 day	14 May 2018, IRT Conference Room, HSTU, Dinajpur
(b) <b>Workshop on</b> Identification and economic analysis of existing agroforestry practices in the northern region of Bangladesh for better agroforestry practices	27	03	30	01 day	27 June 2018, IRT Conference Room, HSTU, Dinajpur

## C. Financial and physical progress

**Fig in Tk**

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	688,810	636,098	657,767	(21,669)	95 %	staff recruitment late
B. Field research/lab expenses and supplies	952,000	903,914	746,075	157,839	90%	short time
C. Operating expenses	180,000	170,919	168,558	10761	100%	-
D. Vehicle hire and fuel, oil & maintenance	160,000	151,875	126,789	25,086	90%	short time
E. Training/workshop/seminar etc.	123,100	116,544	122,352	(5,808)	100%	-
F. Publications and printing	105,000	99,798	91,228	8,570	100%	-
G. Miscellaneous	50,000	47,490	47,132	358	100%	-
H. Capital expenses	157,500	157,500	157,230	8375	100%	-
<b>Total</b>	<b>2,416,410</b>	<b>2,284,138</b>	<b>2100626</b>	<b>183512</b>		

**D. Achievement of Sub-project by objectives:**

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
i) To identify and document the existing agroforestry practices of northern part of Bangladesh	Literature review collection Questionnaire preparation, Field survey and Field measurement	Database on existing practices are prepared and preserved in the Department. Field survey and field measurements were conducted in Nilphamari, Dinajpur, Joypurhat and Natore districts, Photo documentation of different agroforestry practices were done and kept in the Department.	Database will be helpful for the future prospective students. Also awareness and motivation were created among the farmers.
ii) To analyze economic value of the existing agroforestry practices	Analysis of input cost, social and environmental consideration and output benefits.	Economic, social and environmental suitability of different agroforestry practices are be evaluated. Four theses are prepared and documented in the Department for further references	Potential agroforestry practices were economically evaluated which will be helpful for the adoption of profitable agroforestry practices.
iii) To suggest improved agroforestry practices for the farmers.	Training of farmers Organization of workshop Conduction of experiments in the farmers' field.	Improved agroforestry practices for the farmers were found out and suggested. Agroforestry farmers and Agroforestry service providers/ policy makers are trained up. Preparation of training manual	Motivated on area based agroforestry practices which are helpful to achieve the targeted goal of the sub-project.

### E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc. Farmers Training Manual	-	01	Farmers' Training Manual on evsjv†`†ki DËivÂ†j K...wlebvqb cÖhyw <sup>3</sup> Dbœeq†bi Rb`` we``gvb K...wlebvqb Pvl c×wZ wPwÝZKiY Ges A_@%bwZK we†kølbÓ
Journal publication	03	1	Rahman M. S.*, Roy P. R., Bari M. S. and Sarmin I. J. (In press).Cost- benefit analysis of different agroforestry systems of Kaharole upazila of Dinajpur district. <i>International Journal of Agroforestry and Silviculture</i> , ISSN 2375-1096 Vol. 6 (xx), pp. xxx-xxx, xx, 2018
Information development	-	-	-
Other publications, (Thesis )	-	04	1) Cost- benefit analysis of different agroforestry systems of Kaharole upazila of Dinajpur district 2) Identification and economic evaluation of different agroforestry systems of Jaldhaka upazila of Nilphamari district 3) Socio economic assessment of agroforestry systems : a case study of Gurudaspur upazila, Natore 4) Identification and economic evaluation of agroforestry systems of Panchbibi upazila under Joypurhat district

### F. Technology/Knowledge generation/Policy Support (as applied):

#### i. Generation of technology (Commodity & Non-commodity)

Commodity: Different innovative and traditional agroforestry practices were identified under orchard, cropland and homestead agroforestry systems in the northern region of Bangladesh. Among the practices, fruit and fast growing timber tree based agroforestry along with crops were identified. Pictorial documentation was done in the Department. Among the different categories of agroforestry practices, most profitable practices were varied in places, e.g. highest profitable practice was mango and guava in Kaharole upazila, betel nut was in Jaldhaka, mahogany + eucalyptus was in Panchbibi upazila and mango+ litchi was in Gurudaspur upazila.

Non-commodity: New knowledge was discovered about the agroforestry problems and prospect in field level which will be helpful for the future study for the agroforestry researchers. Examples of problems are marketing

problems of agroforestry product, social conflict when trees are grown between two owners land, lack of credit and motivation, lack of training, lack of quality planting materials etc.

#### **ii. Generation of new knowledge that help in developing more technology in future**

Economic profitability of agroforestry practices varied by its systems, species matching and spacing maintained in different places. There are some potential agroforestry practices in the farmer's field also in location basis, e.g. highest profitable practice was mango and guava in Kaharole upazila, betel nut was in Jaldhaka, mahogany + eucalyptus was in Panchbibi upazila and mango+ litchi was in Gurudaspur upazila. Future research should be conducted on the area specific farmer's innovative practices to replicate in other areas of the country.

#### **iii. Technology transferred that help increased agricultural productivity and farmers' income**

The technology that transferred was to practice mixed cropping in the field instead of mono cropping by calculating their economic value. Mixed cropping includes both fruit and timber species along with seasonal crops. Suggested fruit trees are mango, guava, litchi, etc and timber trees are mahagoni, ghora neem, sissoo etc along with various seasonal crops like brinjal, tomato, garlic, potato etc for the northern part of Bangladesh.

#### **Policy Support**

As orchard agroforestry system provided more net income in spite of its higher initial cost, policy makers should give initial loan and provide quality planting materials to the farmers to grow profitable orchard agroforestry to get maximum benefit from a unit piece of land for northern part of Bangladesh.

#### **G. Information regarding Desk and Field Monitoring**

i) **Desk Monitoring** [description & output of consultation meeting, monitoring workshops/seminars etc.):

Technical Division/ Unit, BARC along with internal monitoring team of HSTU were present on a workshop on the project activities on 21.03.2018 at HSTU and were satisfied about the project progress.

ii) **Field Monitoring** (time & No. of visit, Team visit and output):

Technical Division/ Unit, BARC along with internal monitoring team of HSTU visited one of the research fields located at Kaharole upazila, Dinajpur on 21.03.2018 and were satisfied without raising any objection.

## **I. Lesson Learned/Challenges**

- i) For agroforestry research, on farm investigation is very important
- ii) Spacing of tree plantation and age of tree seedlings should be standardized
- iii) Frequent farmers field visit and their feedback are very important to draw the conclusion

## **J. Challenges**

Farmers are very busy at daytime. They have little time to co-operate the research activities. Sometimes, they expect additional monetary or other type of vested interest which is quite bothering for proper investigation.

Signature of the Principal Investigator  
Prof. Dr. Md. Shoaibur Rahman  
Date .....  
Seal

Counter signature of the Head of the  
organization/authorized representative  
Prof. Dr. Md. Tariqul Islam  
Date .....  
Seal

**11.2.10 Photo plates of Jaldhaka upazila**



Plate 5: Koroi with paddy field



Plate 6: Eucalyptus with paddy field



Plate 7: Information collection using questionnaire



Plate 8: Ghora neem- paddy based agroforestry

Plate 5-8: Different agroforestry practices at Jaldhaka upazila of Nilphamari district