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Full Length Research Paper

Cost-benefit analysis of different agroforestry systems and practices of Kaharole Upazila of Dinajpur District

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Abstract

A study was carried out to evaluate the costs and benefits of three agroforestry systems like homestead, cropland and orchard agroforestry systems of Kaharole upazila under Dinajpur district of Bangladesh. An extensive field survey and measurements were conducted during July 2017 to January 2018 at different unions and villages of Kaharole upazila. A multistage random sampling procedure was followed to select the study area. Sixty agroforestry practices including 20 homesteads, 20 orchards and 20 croplands were evaluated for cost and benefit analysis. Initial three years costs and income data were collected from the field survey. Results of the production cost showed that significantly maximum production cost was in orchard agroforestry system (Tk. 98987 per ha.) followed by cropland (Tk. 90238 per ha.) and minimum in homestead system (Tk. 10854 per ha.) in the 1st year. Production cost was recorded decreased while income was recorded increased in the successive years in all the systems. The net income indicated that orchard agroforestry system was financially more profitable than cropland and homestead agroforestry systems, but the benefit-cost ratio (BCR) was higher in homestead as well as cropland agroforestry systems and lower in orchard agroforestry system. 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.

Keywords: Homestead agroforestry, cropland agroforestry, orchard agroforestry, cost and income, BCR.

INTRODUCTION

Deforestation of natural tropical wet deciduous forest is a serious problem in the northern part of Bangladesh. The main cause of soil erosion and land degradation is the deforestation of natural forests (Islam and Sato, 2012; Barbier, 1998). The total forest land area of the country covers about 13.36% of the land area (BBS, 2013). Conversely, actual tree coverage is less than 10.20% (FAO, 2011). In this alarming situation, agroforestry can play an important role to arrest the rapid deforestation of forests by satisfying the local need of timber, fuel wood, fodder and fruits and also contribute a significant role in improving the economic status of the farmers of Bangladesh (Chouhan *et al*., 2017; Hafizul, 2007). Farmers in Bangladesh are practicing agroforestry for a long time ago. But it is a matter of sorrow that the farmers of Bangladesh could not make a smart profit because there is not enough research based on the economic analysis of the exist-

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ing agroforestry practices in Bangladesh (Pandey *et al*., 2016). Therefore, it is a burning topic to do research in the field of agroforestry.

The common agroforestry systems followed by the farmers of Bangladesh are cropland agroforestry, orchard agroforestry and homestead agroforestry (Chakraborty *et al.,* 2015). Cropland agroforestry is a traditional and or innovative land use system where different tree species are grown naturally or planted on agricultural lands and are purposely retained by the farmers for different household utilities and also for cash income in Bangladesh (Chakraborty *et al.,* 2015; Abedin and Quddus, 1991; Abedin *et al.,* 1987). Various patterns of cropland agroforestry systems are practiced in different agro-ecological regions of Bangladesh which reflects biophysical and social variations (Shams, 2013). Trees are planted on the borders or within the field, systemically or at irregular intervals, usually with crops such as rice, wheat, pulse, jute, oilseed, sugarcane, vegetables and others, and farmers also grow shade-tolerant crops such as turmeric, ginger and aroid when trees have high canopy coverage (Miah *et al.,* 2002; Hasan *et al.,* 1997). Orchard agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. It combines shrubs and trees in agricultural and forestry technologies to create more diverse, productive, profitable, healthy, ecologically sound, and sustainable land-use systems (*USDA National Agroforestry Center, 2015).*

Many economic studies of agroforestry systems have been conducted (e.g. Harou,1983; Hoekstra, 1987; Husak and Grado, 2002) in different countries. Generally, these studies examine the financial costs required to establish, manage, and produce various combinations of agricultural and timber crops, potential revenues from different agroforestry alternatives, and profitability of adopting agroforestry practices. But unfortunately no adequate comprehensive research on the cost and benefit of different agroforestry systems were done in the northern part of Bangladesh (Alam, 2008). Hence, there is a lack of realistic information and knowledge on the economic analysis of different practices of homestead, cropland and orchard agroforestry in northern region. Considering the above circumstances, the present study was undertaken to screen the best profitable agroforestry systems of Kaharole upazila under Dinajpur district of Bangladesh.

MATERIALS AND METHODS

Study Area

The experiment was conducted in the Kaharole upazila of Dinajpur district of Bangladesh which lies in between 25°44' and 25°53' north latitudes and in between 88°30' and 89°43' east longitudes. This study follows a multistage random sampling procedure. Firstly, Dinajpur district is purposively selected from the northern region of Bangladesh. Consequently, out of 13 upazilas (sub-districts) in the Dinajpur district, Kaharole upazila is randomly selected. Out of 6 unions of Kaharole upazila, 4 unions were selected randomly taking 5 villages in each union and from each village 3 agroforestry (AF) practices/systems were selected (Figure 1). Therefore, a total of 60 AF practices (4 unions × 5 villages × 3 AF practices/systems) were selected for the study representing about 20% farmer population who are currently practicing AF. Due to various practices and scattered location, unequal proportions of AF practices were drawn from the villages.

Data collection

An intensive household survey was carried out with a pre-tested questionnaire format to fulfill the objectives of the study during July 2017 to January 2018. Independent variables were the different time periods (in years) and dependent variables were production cost, gross income, net income and benefit cost ratio.

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 (Chakraborty *et al.,* 2015).

Data analysis

Annual production cost and income of a farmer was measured in taka on the basis of the total yearly production (land preparation cost, labor cost etc.) and income (fruit, crop, timber etc) (Ahmed, 1997). 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 (Kibria and Shaha, 2011). The B–C ratio, which indicates the rate of return per unit of cost, will be calculated based on the following formula (Kibria and Shaha, 2011):

$$B - C = \frac{\sum_{t=0}^{n} \frac{Bt}{(1+r)^t}}{\sum_{t=0}^{n} \frac{Ct}{(1+r)^t}}$$

where Bt is the benefits accrued over the years, Ct, the cost incurred over the years; t, the time period; i, the interest rate. Three years cost and income data were collected and seven years data were forecasted with

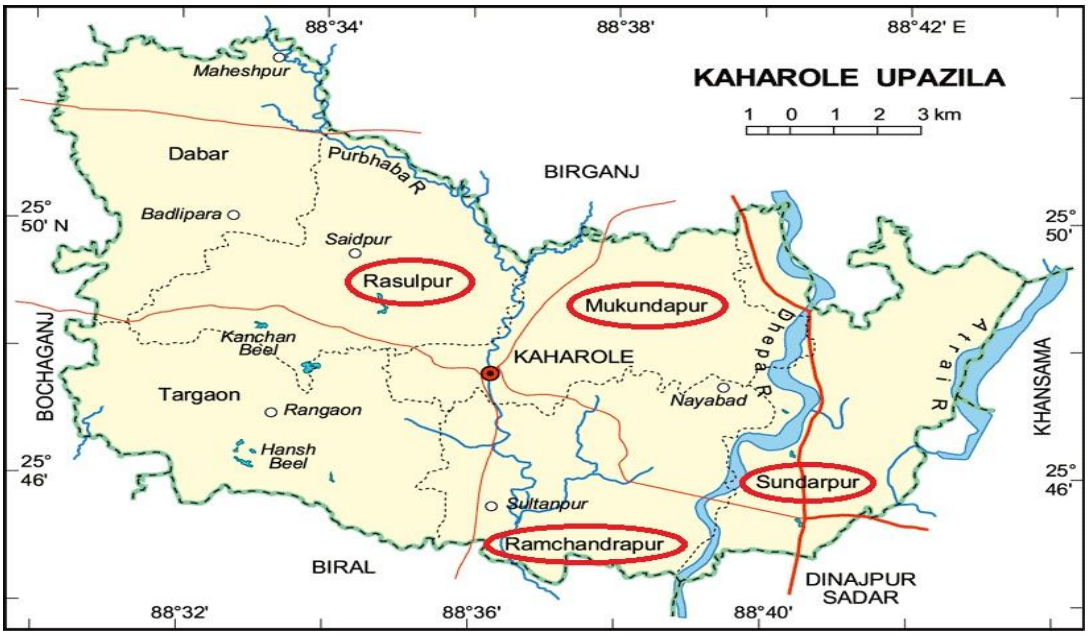

Figure 1. Map of Kaharole upazila showing the study area (Source: Banglapedia).

the help of regression line in MS Excel. The linear regression equation (Montgomery and Vining, 2012) is

Y= a + bX

Here,

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

,

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 (Lopes, 2011) 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.

RESULTS

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 4rth 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 = -2006 x + 13530, for cropland as y = -22089x + 12157 and for orchard as y = -22677x + 16810.

Income of agroforestry systems

Figure 3 shows the gross income of homestead, cropland and orchard agroforestry systems. 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

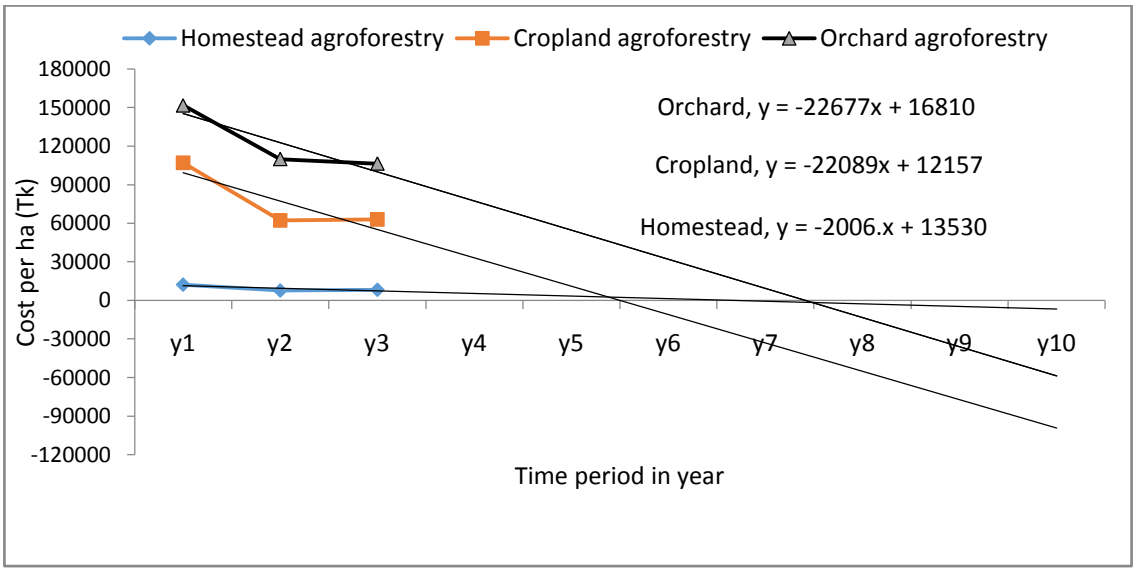

Figure 2. Production cost of homestead, cropland and orchard agroforestry systems of agroforestry of Kaharole upazila.

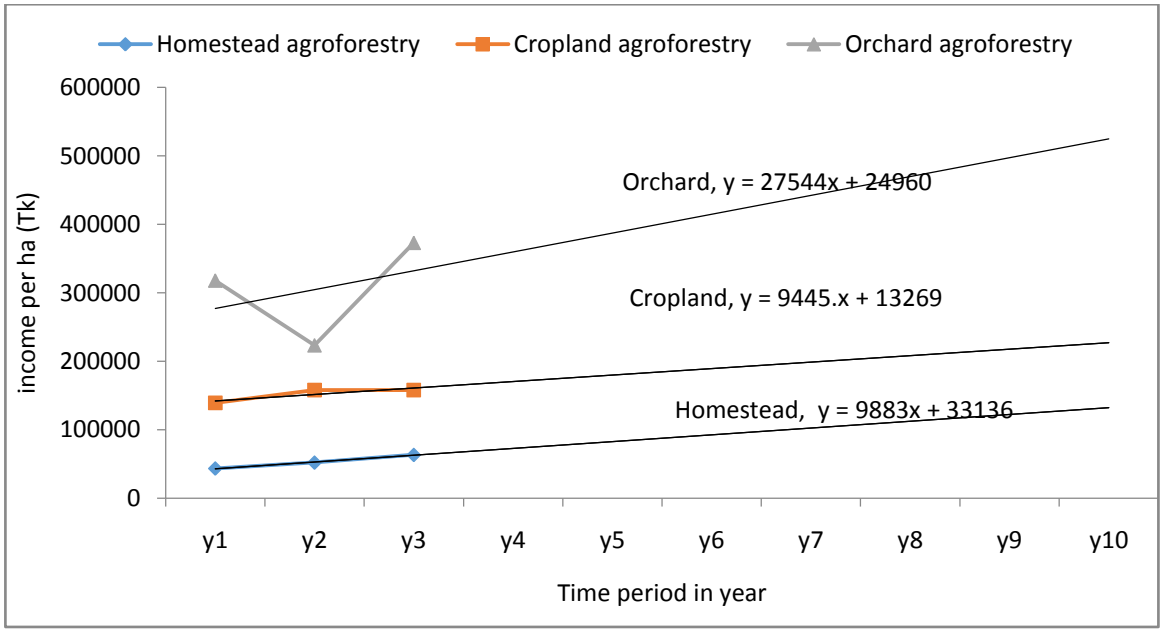

Figure 3. Gross income of agroforestry systems of Kaharole upazila.

increasing trend of gross income in successive years.

Net income of agroforestry systems

Figure 4 shows the net 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 increased in subsequent years. Regression line shows the forecasted net income from

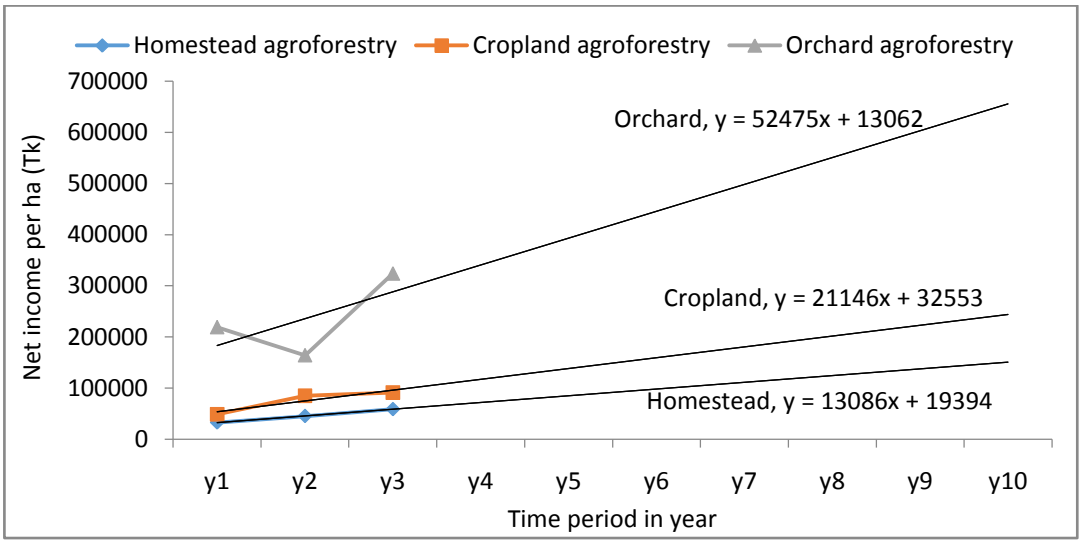

Figure 4. Net income of different agroforestry systems of Kaharole upazila.

4th to 10th year. The trend lines indicate 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.

Benefit Cost Ratio (BCR) of agroforestry systems

Benefit cost ratio (BCR) 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 BCR was recorded 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 BCR 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 as 6.68. The regression models of BCR of homestead, cropland and orchards are shown in figure 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.

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).

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 and guava based agroforestry practices and lowest net income was recorded in jujube based agroforestry practices.

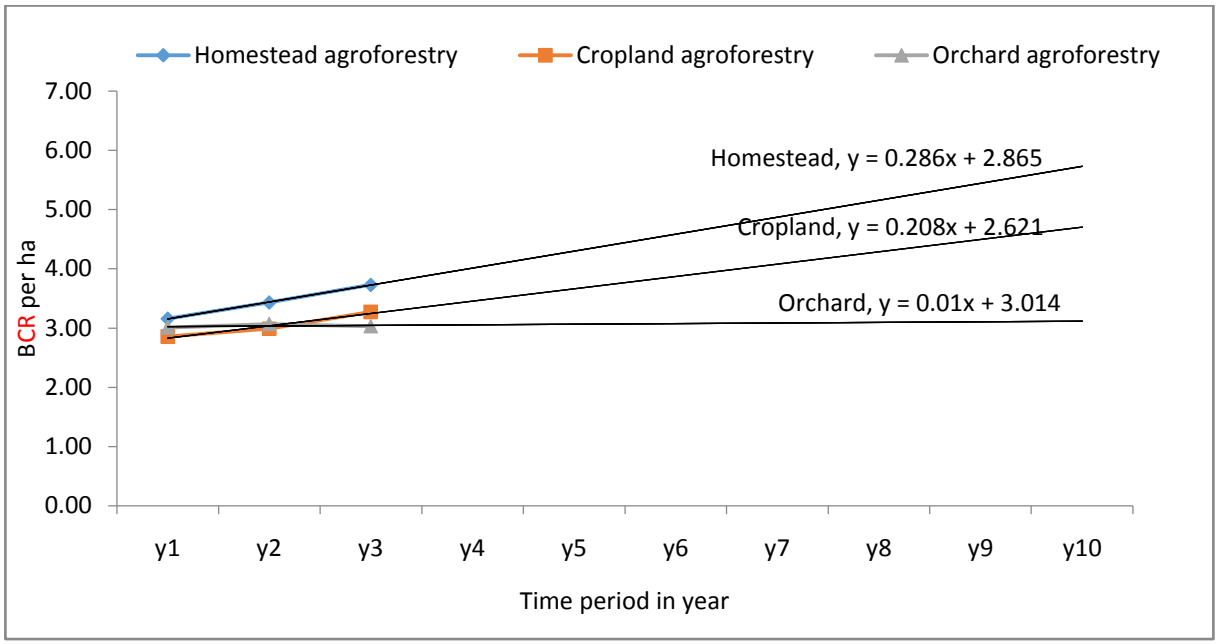

Figure 5. Benefit cost ratio of different agroforestry systems of Kaharole Upazila.

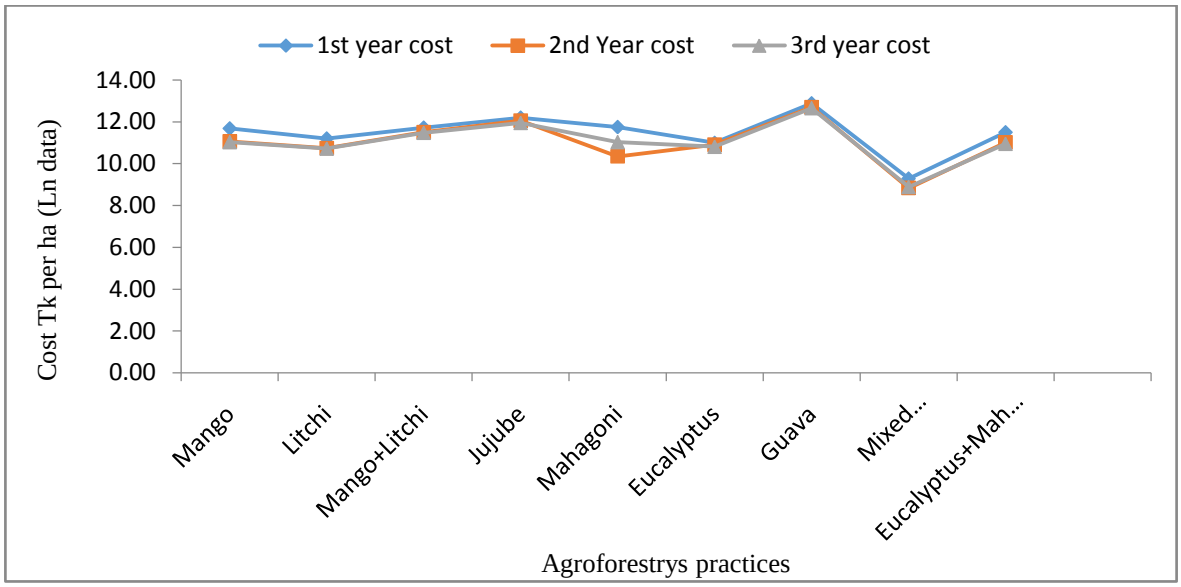

Figure 6. Production costs of different agroforestry practices of Kaharole Upazila (Natural log transformed data).

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 + mahagony, 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).

DISCUSSION

Cost

Comparing the initial costs of three agroforestry systems, highest cost was recorded in orchard agroforestry

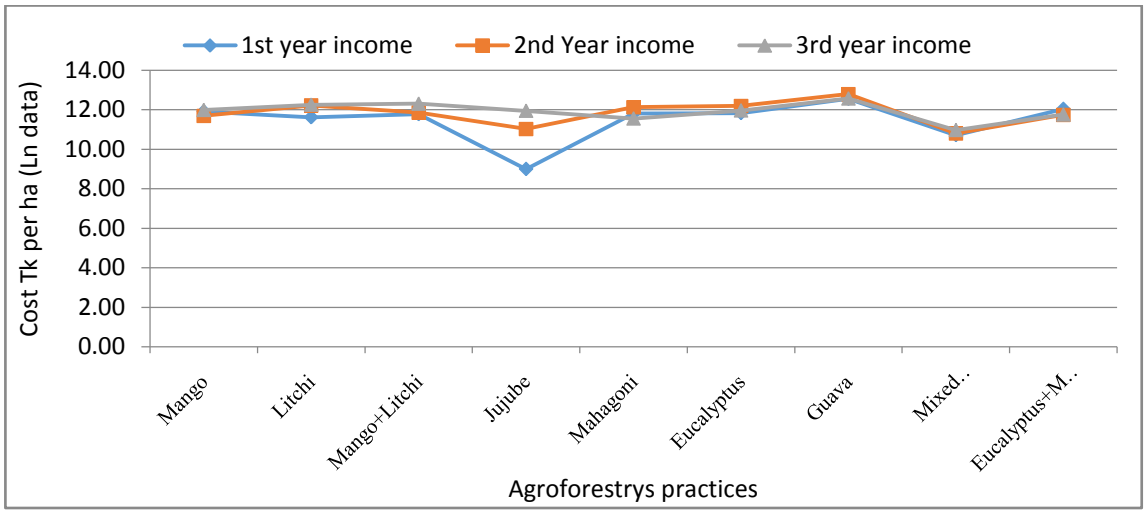

Figure 7. Income of different agroforestry practices of Kaharole upazila.

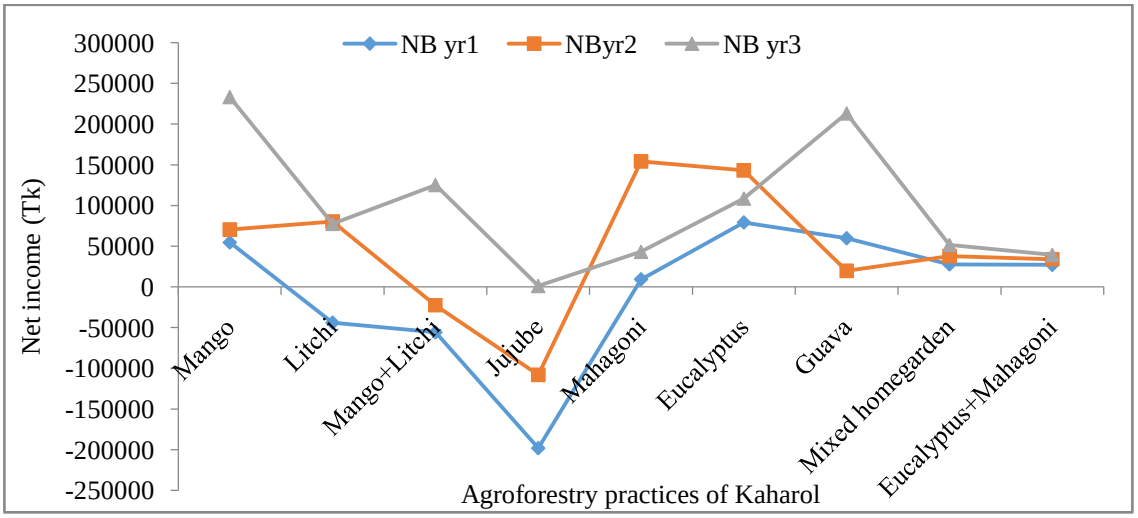

Figure 8. Net income of different agroforestry practices of Kaharole upazila.

followed by cropland agroforestry and lowest cost was recorded in homestead agroforestry system. This is because in orchard agroforestry, intensive care was 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) and 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

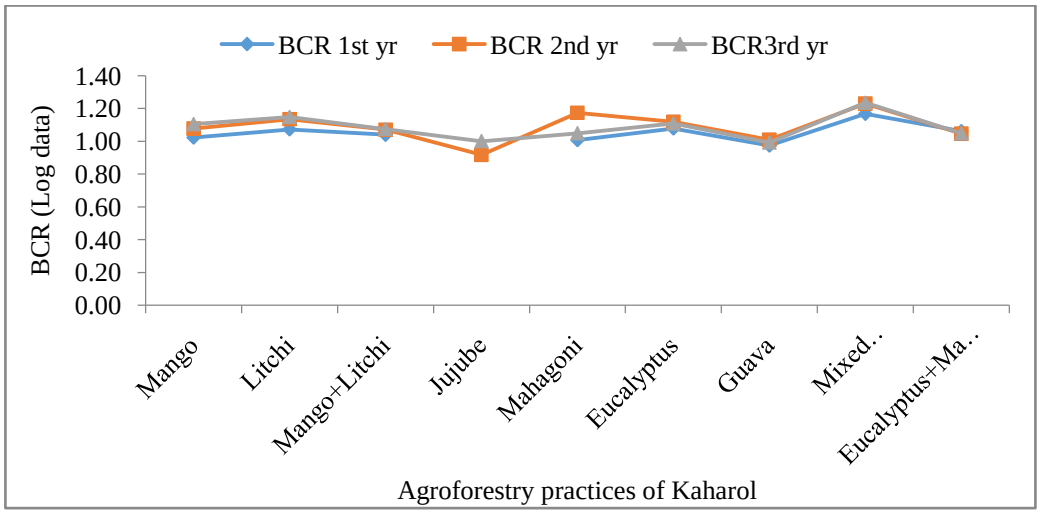

Figure 9. Benefit cost ratio of different agroforestry practices of Kaharole Upazila.

agroforestry offers positive monetary and non-monetary benefits.

Income

From the overall income of three agroforestry systems, it is seen that income of orchard agroforestry system (TK. 317888/ha) is highest followed by cropland (TK.138987/ha) and homestead agroforestry systems (Tk. 52027/ha). 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.

Benefit-cost ratio

In case of homestead agroforestry practices first year benefit cost ratio was recorded (3.16) and it was increased in successive years. Highest benefit cost ratio was recorded at ten year (6.68). In case of cropland agroforestry practices first year benefit cost ratio was recorded (2.85) and it was increased in successive years. Highest benefit cost ratio was recorded at ten year (5.23). 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 recorded (3.01) and it was increased in successive years. Highest benefit cost ratio was recorded at ten year (3.12). Benefit cost ratio was increased because in successive years cost was less than income. 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). 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. This study concluded that integration of agroforestry practices into traditional farming systems yields greater rates of return than monoculture practices alone.

CONCLUSION

From the findings of this study it can be concluded that the cost of orchard agroforestry system was higher than

cropland and homestead agroforestry systems. Homestead agroforestry system had lowest cost and lowest income than the other systems while highest income was recorded in orchard agroforestry system. As a result net income was recorded highest in orchard system and lowest in homestead agroforestry system. On the other hand benefit cost ratio (BCR) was high in homestead and cropland agroforestry systems. BCR of orchard agroforestry system was lowest because of its high cost of production. As orchard agroforestry system provided more net income in spite of its higher initial cost, farmers should give more emphasis to grow orchard agroforestry by minimizing the initial cost. 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.

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