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RESEARCH PAPER

LAND USE PATTERNS AND THE SCALE OF ADOPTION OF AGROFORESTRY IN THE RURAL LANDSCAPES OF PADMA FLOODPLAIN IN BANGLADESH

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ABSTRACT

This research was conducted in six typical villages of Northern Bangladesh. A sample of 170 farmers was selected. Research indicates that the farmers practising agroforestry own small farms and the income of agroforestry helps them to reduce their poverty, maintain their socio-economic needs and sustain their livelihoods. Agroforestry is not a new concept in the study area. The people have been practicing agroforestry traditionally in the form of home gardens, hedgerows and alley cropping. Homestead agroforestry is an age old practice. Alley cropping and hedgerow agroforestry systems are comparatively new. Yet alley cropping is now most popular and is widely accepted in the study area because of its socio-economic advantages and environmental sustainability.

Key words: alley cropping, boundary planting, hedgerows, indigenous knowledge, socio-economic benefits.

INTRODUCTION

Bangladesh, with its unique landscape of forests, uplands, plains and wet lands and a diversified flora and fauna, lies across the Tropics of Cancer and the 90° Meridian East. It is a densely populated country with a population of more than 158 million – with an annual growth rate of 1.7 percent – in some 68,000

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villages in a total area of about 386,000 ha. The rural population makes up 74 percent (ESCAP, 2007). Bangladesh has a favourable climatic and hydro-edaphic conditions supporting intensive agriculture. Villages of Bangladesh have a long heritage of growing trees along with other perennial shrubs and herbs. Homestead agroforestry is an operational unit in which a number of crops including trees are grown with livestock, poultry and/or fish production, mainly for the purpose of satisfying the farmers basic needs (Akhter *et al.,* 1997). It is also a part of the long heritage of traditional agroforestry practices in Bangladesh as well as in other regions of Asia (Abedin and Quddus, 1991; Abedin *et al.*, 1990; Siddiqui and Khan, 1999). NTFPs and vegetables gardens are found in the agroforestry of poorer households (Siddiqui and Khan, 1999).

Agroforestry systems are most extensive in developing countries where approximately 1.2 billion poor people depend directly on a variety of agroforestry products and services (IPCC, 2000). In the five sub-Sahara African case studies in Franzel and Scherr (2002), agroforestry is shown to have potential to increase farm incomes and solve difficult environmental problems. It is financially more profitable to local farmers in comparison with traditional cultivation, beside its other economic and social benefits. Thus, it can be a potential alternative cultivation practice that helps to enhance poverty reduction and transition to permanent cultivation (Mai, 1999).

With an increased rate of deforestation and limitations to the state forestry activities, agroforestry has now assumed a special significance. The practice may be viewed as technology with considerable potential for the reduction of rural poverty. This article is a modest attempt to identify the nature, land use patterns and scale of the adoption of agroforestry in the Padma floodplain of rural Bangladesh.

MATERIALS AND METHODS

Six villages '**Samsadipur**', '**Capasia**', '**Chak Capasia**', '**Guabasnia**', '**Baduria**' and '**Mirkamar**i' of Rajshahi district in the Padma floodplain in Northern Bangladesh were selected. The river Padma, that drains from the Gangotri Glacier of the Himalayas (located in Uttaranchal, India in a region bordering Tibet) and flows through India and Bangladesh towards the Bay of Bengal, borders this area. The climate is "tropical monsoon" with a maximum mean temperature of about 35°C during the months of April, May, June and July; and a minimum temperature in January of about 10°C. The annual average air humidity is 80% and the annual average rainfall is over 1,400mm. The topography is that of a flood plain with an average elevation some 20m above sea level and loamy soils. The villages were selected for their experience with agroforestry practices in an area where the researchers were familiar with the culture, norms and local language, and had access to data previously collected in the area.

The area is somewhat remote with poorest infrastructure, production and social conditions. Most of the inhabitants are subsistence farmers with a very low

standard of living. People practise agroforestry traditionally and the increasing trends of its adoption are seen in the area. Most of the farmers are engaged in traditional farming growing the main annual crop of rice with some wheat and sugarcane – and with beans and vegetables as intercrops.

Sample selection

Very few farmers were found who were not practising agroforestry in some form or other, but 60 traditional farmers were found and selected in order to determine their reasons for not practising agroforestry. 110 other farmers who were practising agroforestry on various scales and using various patterns were selected purposively to provide as wide a range of information as possible.

Data collection and analysis

The primary data were collected from July 2005 to January 2006 by:

- rapid rural appraisal (RRA) for basic information on the farms;
- short structured interviews with the 60 traditional farmers – focusing especially on the reason for non agroforestry system adoption;
- structured interviews with the 110 agroforestry farmers – focusing especially on their experience, land use pattern, benefits and reason for agroforestry adoption;
- direct observation and
- interviews with five groups focussing on species combination and motivation for adopting agroforestry;
- interviews with key informants from Government, non-government and public organisations.

Secondary data were obtained from statistical yearbooks, local administrative records and various related sources.

AGROFORESTRY DEFINED

GoI (2001) defined agroforestry as "a sustainable management system for land that increases overall production, combines agricultural crops, tree crops and forest plants and or animals simultaneously or sequentially and applies management practices that are compatible with the cultural patterns of local population". World Agroforestry Centre (ICRAF) defined, "Agroforestry is a dynamic ecologically based, natural resource management system that through the integration of trees in farm and rangeland, diversifies and sustains small holder production for increased social, economic and environmental benefits."

Agroforestry is a form of multiple cropping which satisfies three basic conditions:

(1) there exists at least two plant species that interact biologically,
(2) at least one of the plant species is a woody perennial, and
(3) at least one of the plant species is managed for forage, annual or perennial crop production.

Summarising, agroforestry is a land management system with a woody perennial as one of the components. It optimizes land productivity by involving positive interactions between its components in time and space.

RESULTS

The Nature of Agroforestry

The people of the study area have a tradition of practising agroforestry; recently their practices have been reinforced by the need for socio-economic and environmental sustainability. Two common agroforestry models were found in the study site:

1. Homestead Agroforestry
2. Cropland Agroforestry
   a) Boundary Plantation (hedgerows)
   b) Alley Cropping

1. Homestead agroforestry

Homestead agroforestry consisting of an assemblage of plants which includes trees, shrubs, and herbaceous plants, growing in or adjacent to a homestead or home compound, has a long tradition in the study site. These are planted and maintained by members of the household with their products intended primarily for household consumption; they have considerable ornamental value and provide shade to people and animals.

Homestead agroforestry exemplify all the agroforestry characteristics of:

- an intimate mix of diversified agricultural crops and multipurpose trees fulfils most of the basic needs of the local population;
- the multi-storeyed configuration and high species diversity help reduce the environmental deterioration commonly associated with monocultural production systems;
- producing sustained yields in a resource-efficient way.

In spite of the very small average size of the management units, homestead agroforestry systems are characterized by high species diversity and usually 3–4 vertical canopy strata, which result in intimate plant associations. The layered canopy configurations and combination of compatible species are the most conspicuous characteristics of all systems. Contrary to the appearance of random arrangement, the gardens are usually carefully structured systems with every component having a specific place and function.

All homestead agroforestry consist of an herbaceous ground layer, a tree layer at upper levels, and intermediate layers between. The lower layer can usually be partitioned into two, with the lowermost (less than 1 m height) dominated by different vegetable and medicinal plants, and the second layer (1–3 m height) being composed of food plants such as banana, papaya, yam, etc. Various fruit trees, some of which would continue to grow taller, dominate the intermediate layer of 3–10 m height. The upper tree layer consists of emergent, fully grown timber and fruit trees occupying the uppermost layer of over 25 m height, and medium-sized trees of 10–20 m occupying the next lower layer. This layered structure is never static; the pool of replacement species results in a productive structure that is always dynamic, while the overall structure and function of the system are maintained.

The production of the homestead gardens provides the farmers with produce for home consumption and a surplus for the market supplying the urban population.

2. Cropland agroforestry

Cropland agroforestry combines the production of agricultural crops and trees in the cropland through intercropping. Two types of cropland agroforestry models were found in the study area, both rely on urban markets for the sale of produce surplus to the farmer's own needs.

a) Boundary plantation (hedgerows)

Boundary plantations combine perennial, preferably leguminous trees or shrubs, grown around an arable crop. During the cropping phase the trees are pruned and the prunings used as green manure or mulch for the arable crop to improve the organic matter status of the soil and to provide nutrients, particularly nitrogen. Boundary plantations as windbreaks also protect crops. Commonly used trees are prickly acacia (*Acacia nilotica*), betel-nut (*Acacia catachu*), eucalypt (*Eucalyptus brassiana*) and rose wood (*Dalbergia sissoo*). Eucalypt and rose wood are fast growing trees with high timber values; prickly acacia and betel-nut also have high commercial values. Boundary plantations are not so popular in the study area in spite of their benefits:

- Improved crop performance due to the addition of nutrients and organic matter to the soil/plant system;
- A reduction of the use of chemical fertilisers;
- An improvement in the physical nature of the soil environment;
- On sloping land, the tree rows act as a physical barrier to soil and water movement, resulting in significant reductions in erosion losses (Paningbatan *et al.* 1989); and
- The provision of additional products such as forage, firewood or stakes.

b) Alley cropping

This model is the most popular and is widely accepted in the study area. Multipurpose species – here, usually Mango (*Mangifera indica*) – trees are planted in rows. Paddy (*Oryza sativa*), wheat (*Triticum aestivum*), sugarcane (*Saccharum officinarum*), papaya (Carica papaya), banana (*Musa species*), ginger (*Zingiber officinale*), turmeric (*Curcuma domestica*) and different types of vegetables i.e., potato (*Solanum tuberosum*), bean (*Dolichos lablab*), datashak (*Amaranthus lividus*), lady's finger (*Abelmoschus esculentus*) are intercropped with the mango trees to provide a cash flow – particularly in the early years after the mangoes have been planted but have yet to yield. Paddy, wheat, sugarcane, papaya and banana are intercropped in the early years (first 12 years), and then the shade-tolerant ginger, turmeric and vegetables are commonly planted later.

Land Use Pattern

All of the farmers in the study area have their own land. At present, an average of 39% of the total of arable land is being used for cropland agroforestry purpose (alley cropping and hedgerow). Farmers' are also practising homestead agroforestry on a further 9% i (Diagram 1). The remainder is under traditional agriculture.

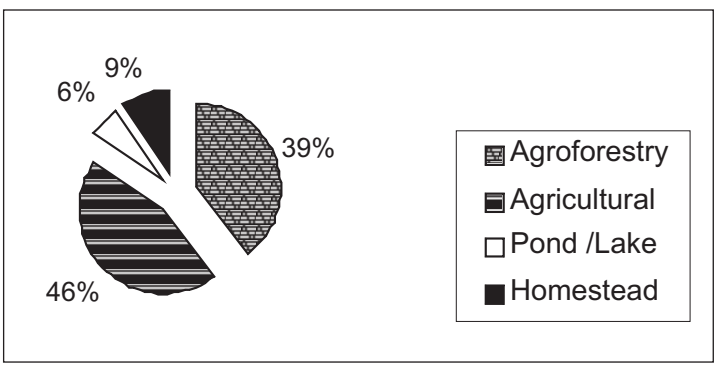

Diagram 1. Farmers land use patterns

Most of the farmers are poor because their total land only averages just over 0.5 ha.(1.35 acres), yet they allocate a significant amount to agroforestry. Nearly 65 % of the farmers have 0.2 ha. (0.50 acres) or less of land under agroforestry (Table1).

Table 2 presents the agroforestry land use pattern compared to total land area. The relationship between area under agroforestry and farm size is weak with a great deal of variation. The areas under agroforestry, though varying greatly in farms of the same size, tends to average around 0.5 ac. regardless of farm size – indicating that the larger farms allocate a small percentage of their land to agroforestry compared to the farmers with smaller farms.

Table 3 tabulates agroforestry land use patterns and incomes (tk.)[1]. Nearly 70% of farmers have an income between tk. 20,001 to tk. 80,000 and must be considered to be poor; they are the main beneficiaries and users of agroforestry.

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TABLE 1

Quantity of agroforestry lands (acre)

Quantity of agroforestry land	Percent
0.50 or less	64.5
0.51–1.00	35.5
Total	100.0
Mean	0.53

TABLE 2

Cross tabulation of farmers total land area and agroforestry lands

Total land area (Acre)	Agroforestry lands (Acre)		Total
	0.50 or less	0.51–1.00	
0.50 or less	7 (6.4%)	–	7 (6.4)%
0.51–1.00	14 (12.7%)	7 (6.4%)	21 (19.1%)
1.01–1.50	32 (29.0%)	7 (6.4%)	39 (35.4%)
1.51–2.00	12 (10.9%)	19 (17.3%)	31 (28.2%)
2.01–2.50	6 (5.5%)	6 (5.5%)	12 (10.9%)
Total	71 (64.5%)	39(35. 5%)	110 (100.0%)

[1]US$ 1 = 69 Taka (tk.) as of May 2006

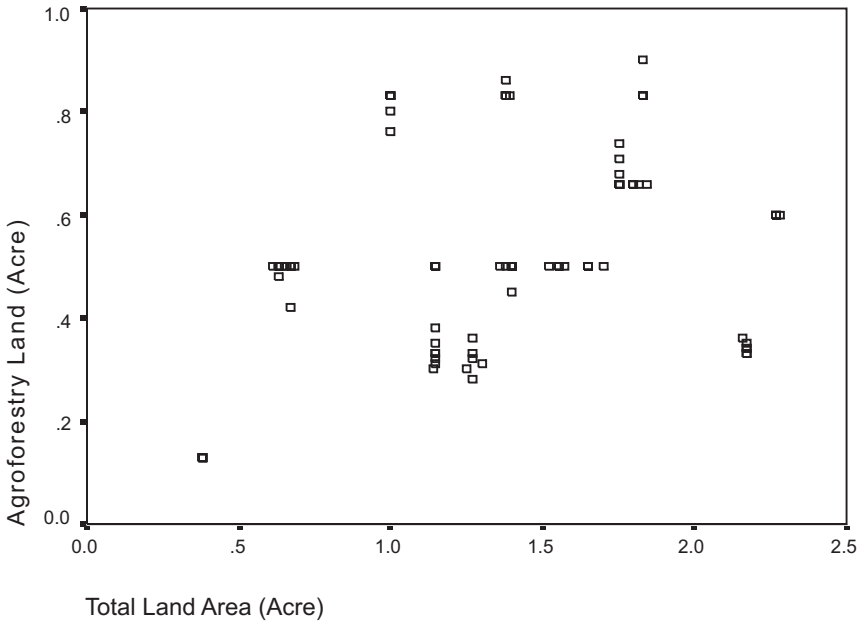

Diagram 2. Scattered plot

TABLE 3

Cross tabulation of farmers' total income and agroforestry lands

Yearly total income (tk.)	Total agroforestry lands (acre)		Total
	0.50 or less	0.51–1.00	
20,000 or less	7 (6.4%)	–	7 (6.4%)
20,001–40,000	12 (10.9%)	14 (12.7%)	26 (23.6%)
40,001–60,000	19 (17.2%)	19 (17.3%)	38 (34.5%)
60,001–80,000	13 (11.8%)	–	13 (11.8%)
80,001–1,00,000	13 (11.8%)	–	13 (11.8%)
1,00,000 +	7 (6.4%)	6 (5.5%)	13 (11.8%)
Total	71 (64.5%)	39 (35.5%)	110(100.0%)

Benefit Distribution

Agroforestry provides economic benefit to the farmers. It is more profitable and less risky than other agricultural options because of the variety of produce and relative stability of their prices. Aside from tree species the advantage of agroforestry is the early return from non timber crops that are interplanted with the tree species. The financial analysis indicates that the average household's harvested agroforestry products over one year are worth approximately tk.,

15,400, compared with that from their agriculture of tk. 8,600. This is despite only 39% of the land is under agroforestry.

Table 4 presents yearly agroforestry income compared to farmers' total income for classes of total farm income. Agroforestry is a major source of their cash income. It contributes nearly half of their total income.

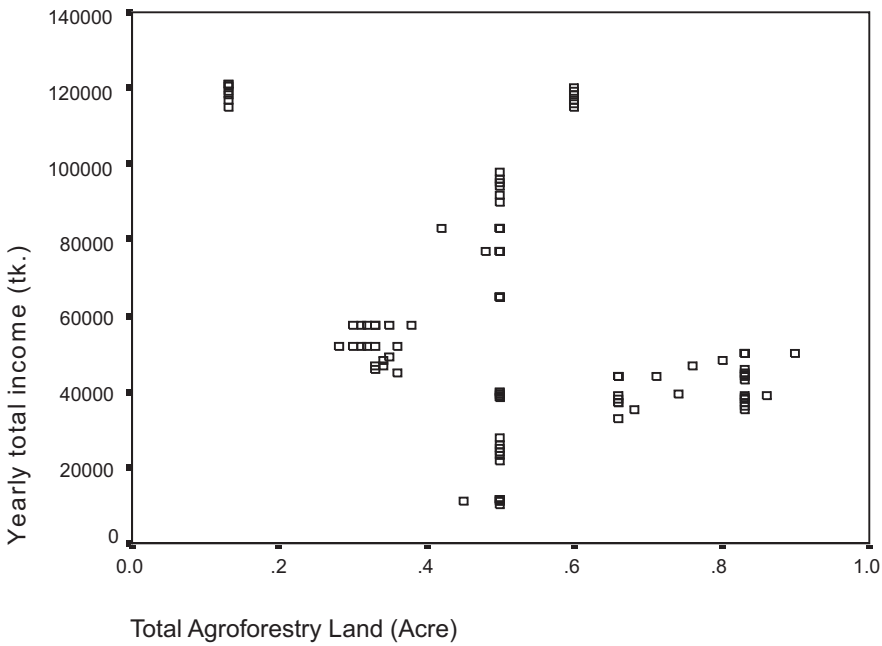

Diagram 3. Scattered plot.

TABLE 4

Cross tabulation of farmers' total income and agroforestry income

Yearly total income (tk.)	Yearly agroforestry income (tk.)				Total
	10,000 or less	10,001–20,000	20,001–30,000	30,001–40,000	
20,000 or less	7 (6.4%)	–	–	–	7 (6.4%)
20,001–40,000	7 (6.4%)	19 (17.4%) *	–	–	26 (23.8%)
40,001–60,000	13 11.9%) *	6 (5.4%)	13 (11.8%)	6 (5.5%)*	38 (34.6%)
60,001–80,000	7 (6.4%)	–	6 (5.4%)	–	13 (11.8%)
80,001–1,00,000	6 (5.4%)	7 (6.3%)	–	–	13 (11.7%)
1,00,000 +	6 (5.4%)	7 (6.3%)	–	–	13 (11.7%)
Total	46(41.9%)	39 (35.4%)	19 (17.2%)	6 (5.5%)	110 (100.0%)

*rounding errors

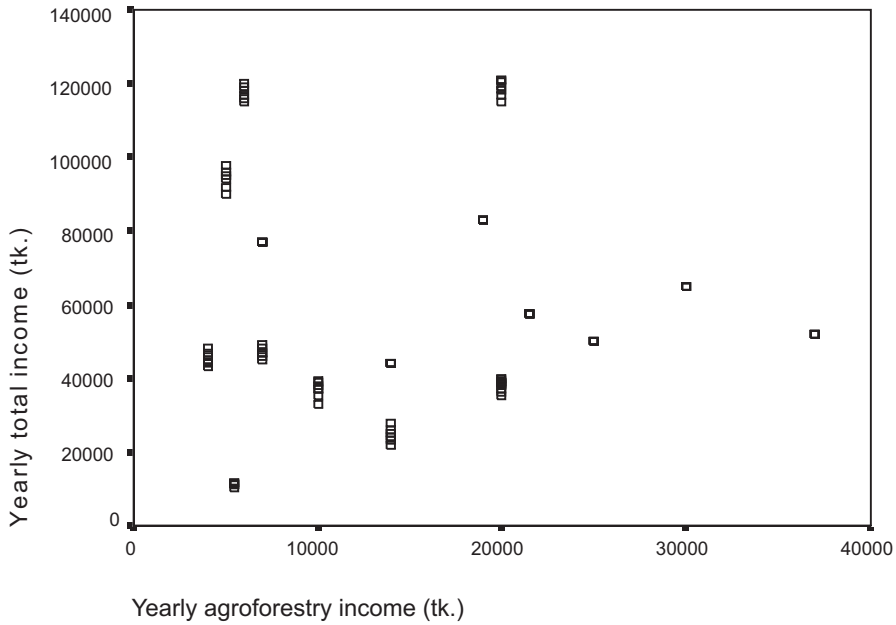

Diagram 4. Scattered plot

Agroforestry Adoption

The majority of the farmers in the study area have a thorough knowledge of agroforestry i.e., planting and raising the seedlings, trees and crops, use of pesticides and fertilizers, etc. All farmers adopted agroforestry for its high profitability. Table 5 lists the other reasons given. Research also indicates erosion control, crop diversification, suitable use of land and space and presence of information and technical assistance are also other important causes for agroforestry adoption.

Sixty traditional farmers (farmer who are not practising agroforestry) were also questioned for identify the reasons for their failure to adopt agroforestry. The main causes given was lack of capital; lack of interest, suitable land, knowledge of agroforestry systems and technical assistance were commonly stated as factors along with the delay in positive cash flows (Table 6).

DISCUSSION

Homestead agroforestry is an old age practice. Alley cropping is the most popular and widely accepted in the study area because of its socio-economic sustainability

Experimental evidence supporting claims of beneficial effects of alley cropping is provided by a number of studies. Kang *et al.* (1981) reported that

TABLE 5

Reasons for Agroforestry Adoption

Reasons	Percent
1) High income	100.00
ii) Influence:	
a. Influence by the peers (other farmers)	23.64
b. Influence by the NGOs	15.45
c. Influence by the GO officials	1.82
d. Influence by the media	10.91
iii) Old age tradition	2.73
iv) Erosion control and soil protection	0.91
v) Crop diversification and risk reduction	1.82
vi) Presence of information and technical assistance	0.91
vii) Suitable use of land and space	4.54

TABLE 6

Reasons for Non-Agroforestry Systems Adoption

Reasons	Percent
1) No knowledge	5.00
ii) No interest	20.00
iii) Lack of capital	58.33
iv) Delay in profit earning	10.00
v) Lack of technical assistance	10.00
vi) Management risk:	
a. Economic (lack of money)	6.67
b. Natural (Flood, drought, storm)	1.67
vii) Unstable market price	3.33
viii) Land is not suitable	13.33

maize grain yields increased from 1.9 t/ha in unfertilized control plots to 3.5 t/ha in plots mulched with *Leucaena leucocephala* (leucaena) from 4 m wide rows. A similar magnitude of response was obtained by Dofeliz and Nesbitt (1984) in the Philippines with *Leucaena* at 4 m row spacing. Evensen and Yost (1990) initially reported positive results from the alley cropping of upland rice and cowpea with rows of *Paraserianthes falcataria* on a Tropeptic haplorthox in west Sumatra, Indonesia, particularly with addition at a low rate of lime. However, yields declined after 4 years and were restored only after fertilizer input was increased.

Poor farmers are the main users and beneficiaries of agroforestry (Table 2 and 3). They practise agroforestry to mitigate their socio-economic needs, and agroforestry is their major source of cash income, which provide nearly half of their total cash income. Alam *et al.* (1996) implies that a good number of landless and marginal farmers earn their livelihood for a particular period of

the year from agroforestry. The cash received from agroforestry are mainly used for purchasing or leasing land, buying bullocks, agricultural implements, supplementing expenses of marriages and social obligations, meeting educational expenses, repaying of loans, etc.

The main incentive for agroforestry adoption in the study area is the prospect of earning high incomes. Some households who do not practise agroforestry have no knowledge of and no interest in it.

Similar results were found in the number of studies. Mai (1999) indicates the main reasons for agroforestry adoption in the Lak district of Dak Lak province in Viet Nam are the prospect of high income earning and the presence of technical assistance. He also found that a lack of knowledge of agroforestry and the lack of capital are the two main reasons for not adopting agroforestry (Feder *et al*., 1988; Thapa, 1998)

In rural India the high income earning and economic competitiveness of tree crops are the main reason for agroforestry adoption (GOI, 2001). Farmers need to invest substantial amounts of money and labour to move from traditional cultivation to agroforestry, and they have no access to credit, and other institutional services required. As a result farmers are forced to continue their traditional land use practices, despite their willingness to change (Lele and Stone, 1989; Rasul and Thapa, 2003).

The agroforestry system has higher establishment costs (Rahman and Farhana, 2005) and entails a break with established routines. If farmers could be motivated, they could easily circumvent the capital constraint by gradual, piecemeal expansion of their agroforestry area, adding a few seeds and seedlings from their own stock each year, just as, for instance, farmers in the Philippines do with investment in terracing (Romero, 2006). What would really be the capital constraint also for a non-agroforestry farmer to plant a few trees with some help from his agroforestry neighbours? “Delay in profit earning”, referring to the lack of capital to bridge the gap before the agroforestry species bear fruit. This argument is similar to the study of Rahman *et al.* (2007), where farmers refer to a time span of less than one year, since even the fast agroforestry species are not as fast as the rice or wheat that mature within a few months. The income of the agroforestry planter will therefore be lower than that of the purely arable farmer for, say, half a year before being compensated by the agroforestry crops. If a farmer spreads the installation of an agroforestry system on, say, 5 percent of his land each year, his income flow would be delayed only once by only that percentage, assuming that in the second year the first year’s agroforestry crops would replace the lost income from the new land converted into agroforestry.

CONCLUSION

Farmers in Northern Bangladesh are practising agroforestry traditionally in the form of homegardens (homestead agroforestry) and many have expanded into cropland agroforestry (boundary plantation and alley cropping).

Agroforestry is more profitable and less risky, than other agricultural options. Aside from the tree species, the advantage of agroforestry is the early return from non timber crops that are interplanted with the trees. The incentives of agroforestry adoption in this area are:

- high income earning supplying an established market,
- the influence and assistance from other farmers, NGOs, GO officials, media,
- old age tradition,
- erosion control and protection,
- crop diversification and risk reduction,
- suitable use of land and space.

The main reasons for some farmers not adopting agroforestry are:

- lack of capital,
- lack of interest,
- lack knowledge on agroforestry systems,
- delay in profit earning,
- lack of technical assistance,
- high risk of crop protection from damage due to some social, economic and natural dangers,
- not have suitable land for this cultivation practice, and
- unstable market price for agroforestry products.

Assuming that people are basically financially motivated, failure to adopt this financially profitable system must be due to lack of capital, knowledge, land, etc. Most of these constraints could be overcome by a gradual adoption – transferring a small area each year from arable crops to agroforestry.

As far as the authors can appreciate, the foregoing is likely to apply in many areas where agroforestry is not a new concept, but is practised on only a restricted scale to meet subsistence needs. The large urban population of Bangladesh supports an existing market structure for agroforestry products that, in turn, supports the farmers.

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