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Impact of Banana Based Agroforestry on Degraded Sal Forest (Shorea robusta C.F. Gaertn) of Bangladesh: a Study from Madhupur National Park

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Abstract

Over three decades various agroforestry systems have been introduced in Madhupur Sal forest in an attempt to check for over-exploitation, encroachment and agricultural expansion. An explanatory survey has been conducted to assess the impacts of banana based agroforestry system through respondents' survey using a semi structured questionnaire, soil properties analysis and quantitative analysis of species diversity. A total of sixty farmers engaged in banana based agroforestry have been interviewed randomly from the two ranges of Madhupur National Park. A total of 50 plots (10m x 10m) were established randomly for quantitative analysis of species and twenty soil samples were collected for soil analysis from two land uses (25 in each) i.e. banana based agroforestry land use and in the Sal forest of Madhupur NP. Results obtained from soil analysis revealed that soil pH condition (4.62) and average organic matter (OM) content (2.57%) were higher in banana based agroforestry soil than that of Sal forest (pH 5.03 and OM 2.02%). Conversely, the amount of moisture content (11.62%) and Sulphur (S) were higher in Sal forest (66.06 µg/g soil). Biological diversity indices were calculated in order to check the status of species diversity for both land use systems. Indiscriminate use of fertilizers, chemicals in soil together with clearing forest for banana cultivation have been reducing the coppicing power Sal trees and destroying the biodiversity of the forest. A sustainable forest management plan giving priority on Sal trees on all degraded areas and creating alternative income generation activities for banana cultivators has been recommended highly in order to maintain the uniqueness of the forest.

Keywords: *Agroforestry, Shorea robusta; Soil properties; Biological diversity indices; Benefits and drawbacks; Bangladesh.*

INTRODUCTION

Sal forest, the inland moist deciduous Sal [Shorea robusta Gaertin.f.] forests of Bangladesh are widely distributed in the districts of Mymensingh, Tangail, Gazipur, Jamalpur, Comilla, Sylhet, Dinajpur, Thakurgaon, Rangpur, and Rajshahi districts covers about 0.12 million hectares of land comprising about 4.7% of the total forest area of the country [1, 2, 12, 36, 26, 41]. These forests are managed under coppice system with a rotation of 25 years. But now almost all the Sal forests are

severely disturbed by the local and ethnic people as these forests are the only natural forest resources of the central and northern parts of Bangladesh where the vast majority of the population settles [38, 26]. The majority of the Sal forests lie in the districts of greater Mymensingh, Tangail and Gazipur districts, which is the largest belt, besides known as "Modhupur Garh", which is comprised of two National Parks: Madhupur and Bhawal National Park [5] and including some patches in the greater Comilla and Sylhet districts of Bangladesh which totally called central plain land Sal forest comprises an area of about 86% of the total Sal forest [2].

Ethnic people living in close proximity to the central plain land Sal forest, such as the Garo, Koch and Hajong, totally depend on forest resources such as food, fuel wood, medicinal plants, construction materials for houses, boats, and furniture, and many other items of trade and commerce to satisfy many of their basic needs [12, 17, 5, 35]. When the government had decided to establish as a national park in Modhupur Sal forest, the indigenous Garos stood strongly against it as they started to think it as a barrier to their natural movement within the forest area [12]. Presently, local Bengali and ethnic people of nearby Sal forest are realizing that, they are not getting timber, fuel wood and other forest products as they got before; so they have started to encroach the forest land and started to practice different types of agroforestry. The areas under encroachments estimated about 0.036 million ha and the number of encroachers are about 100,000 [35] and the deforestation rate is 3.3% per year [6]. As a result the forest area and carrying capacity of the forest is declining day by day and reducing vegetation coverage thus the ecological balance has been threatened and increases natural hazards [37, 40].

Agroforestry has become an effective tool to replenish degradation of Sal forest as it offers direct benefits to the local community from its early stage of establishment. Government of Bangladesh and Non-Government Organizations launched several agroforestry projects throughout Madhupur Sal Forest [34]. In agroforestry practices under Thana Afforestation and Nursery Development Project [TANDP] in November, 1989 selected participants has been allotted 1.0 ha of land to cultivate agri-crops like zinger, papaya, palm kin, banana and pineapple along with supplied tree species of forest department [2]. Side by side a woodlot plantation was also initiated under the same project to meet the local demand of fuel wood and timber but participants show greater preference for agroforestry than woodlot.

This situation turned out to be the perfect ground for the banana, pineapple, lemon and papaya traders to invade the vacant forestland. In a short period of time they also cleared thousands of acres of forestland and converted these land to single banana, pineapple, lemon and papaya gardens and as well as managed under agroforestry systems. In this way the most part of the mentioned forest land are gone under the control of local banana, pineapple, lemon and papaya traders and highly beneficial banana plantation and banana based agroforestry system is one of common factor of degradation of forest [13, 2]. Although, both Forest Department personnel and local Garo's are agree that it is a serious problem for their environment, economy and society but they are unable to do anything due to the forces of political leaders. Three species of banana like Meher-sagor, Amrita-sagor, and Sobri are more cultivated. Banana cultivation is widely practiced in different locations of the forest due to the high and quick economic return to the farmers. But indiscriminate use of fertilizers, pesticides, insecticides and growth hormones decreasing the natural fertility and productivity of the forest soil and increasing soil erosion [13, 14]. So far many studies have been conducted on Sal forest of Bangladesh but study directly on the impacts of banana based agroforestry on soil and forest vegetation has not been conducted yet.

Therefore, the present study explores the impacts of banana based agroforestry on the ecosystems of the degraded Sal forest particularly on Madhupur National Park [MNP] of Bangladesh. The objectives of the present study were to examine the impacts of banana based agroforestry on MNP ecosystem; the species richness on banana based agroforesty landuse and Sal forest, changes of soil properties due to the banana cultivation. The purpose of this study is to provide guidelines to the policy makers as well to the funding agency to develop a sustainable forest management plan that would be preserve the biodiversity of MNP through involvement of local dependent Bengali and ethnic peoples. In order to reach the highlighted objectives following research questions are addressed:

1. Do the soil properties vary between banana based agroforestry land use and Natural Sal forest?

2. Does banana based agroforestry system put any negative impact on soil properties of Sal forest?

3. What is the present status of different species diversity in these two land use systems?

4. What are the benefits and drawbacks of banana based agroforestry system?

Study area profile

Madhupur National Park was established in 1982 with an area of 8438 ha to preserve the significant biodiversity of the area, to provide a pleasant outdoor recreation place and to preserve the historic value of the site. Sal is the dominant species and usually forms 25% to 75% of the upper canopy [17, 10]. The area is located between 23º50′-24 º 50′ N latitude and 89 º 54′-90 º 50′ E longitudes [Fig 1]. It is about 60 km north of Tangail and 45 km south of Mymensingh. According to the Survey of Bangladesh Center for Advanced Studies, the park contains about 176 vascular plant species belonging to 141 genera and 72 families and 60 terrestrial faunal species belonging to 54 genera and 40 families and about 70000 people live in and around the park of which 16000 are tribal population, most of them are Garos [21]. The soil belongs to the bio-ecological zone of Madhupur Sal Tract [28]. The soils have a moderate to strong acidic reaction [39]. The soils are also characterized by low organic matter and low fertility [1]. Climatic condition is moderate, annual rainfall from 2030-2290 mm, annual temperature from 10-37°C, humidity between 60 and 86%, duration of sunshine from 5-9 hours [7]. Sal forests now occur in disjointed and isolated patches of varying sizes and in many cases as islands among cultivated fields and habitations. Sal forests are located on flat topped hillocks intermixed with a network of depressions which are cultivated with paddy, pineapple, lemon and banana. Sometimes even homesteads are also mixed with Sal patches where boundaries are ambiguous due to encroachments [29].

MATERIAL & METHODS

Selection of forest ranges

An exploratory survey on banana plantation in MNP were carried out over during the period of January to June, 2010. The study was based on primary data collection from the respondents on present semi-structured questionnaire, field observation and interview. Under the Madhupur Sal forest area, MNP was selected purposively because this park is degrading day by day by legal or illegal process. From the Madhupur NP, Madhupur and Dokhola forest ranges were selected for the study since the villagers of these range are highly dependent on park for banana based agroforestry.

Respondent selection

A semi-structured questionnaire was developed to elicit relevant information connectivity and dependency on banana based agroforestry in MNP; operational characteristics of the respondents [farmers] such as socio-economic conditions, educational status, livelihood activities, and their dependency on banana based agroforestry system, etc. In order to collect information, age-old persons having long experience in the sector were selected for the interview. Finally, among the total more than 200 farmers about 60 farmers were selected deliberately from Madhupur and Dokhola forest ranges [30 from each].

Sample plot selection

A total of 50 plots [10m x 10m] were established randomly for quantitative analysis of species and soil sample collection in two land uses i.e. banana based agroforestry land use and in the Sal forest of MNP [25 in each] and all the plots were deployed either in the boundary of the forest or in the boundary of the forest having connectivity with the forest. Several studies in the tropics have used sample pots ranging from 10m x 10m to 10m x 50m [3, 11, 8, 15].

Soil sample collection

Twenty soil samples with five replicates were collected from two land uses. Plots for soil sampling were chosen alternatively with attention to cover all slopes and elevation gradient. For each plot four soil samples from 0-20 cm were collected. A composite sample was prepared by mixing soils from two sites.

Data Analysis

Soil sample preparation

In the laboratory, collected moist soil samples were firstly sieved through 10 mm mesh sieve to remove gravel, small stones and coarse roots and then passed through 2 mm sieve. Then the sieved samples were dried under room temperature.

Determination of soil physical and chemical properties

Soil samples were analyzed chemically to determine the soil P^H [using a digital P^H meter HANNA HI 9210N ATC], total nitrogen by Micro-Kjeldahl digestion procedure, phosphorous by Bray and Kurtz method, organic matter by Walkley-Black's wet oxidation method and sulphur was measured using calcium phosphate [27], potassium was determined by the ammonium acetate method [22,18]; soil moisture content, manganese, calcium, boron, magnesium, cupper, iron and zinc were determined according to [20,32] in laboratory of Department of Forestry and Environmental Science and Department of Civil and Environmental Engineering of Shahjalal University of Science and Technology, Sylhet, Bangladesh.

Quantitative analysis of species diversity

Five biological diversity indices such as Shannon-Winner index [H], Simpson index [D], Species diversity index [SDI], Species richness index [R], Species evenness index [E] were calculated to show the quantitative status of species in two land use system. These indices have low sensitivity to sample size and are widely used [9].

1. Species diversity index: $SDI=S/N$…… [30]
2. Species richness index: $R= [S-1] / Ln [N]$……..…….... [24]
3. Shannon-Winner diversity index: $H = -\sum P_iLnP_i$……. [25]
4. Species evenness index: $E= H/Log [S]$……..……. [33]
5. Simpson index: $D=\sum P_i^2$…… [23]

Where, S= total number of species; N= total number of individuals of all the species; n_i is the number of individuals of each species, P_i= [Number of individuals of one species/Total number of individuals in the samples.

RESULTS & DISCUSSION

Demographic features of the respondents

The demographic feature of the surveyed households is represented in Table 1. A total of 60 respondents were interviewed engaged in banana based agroforestry practices. Modal category age class in both ranges is [25-35] years. These data prove that the respondents who are participating in banana cultivation they are middle-aged person and more or less experienced person also. Out of the total 60 respondents participation of male respondents was found highest about 63.33% where female was only 37.67%. Because male are more eager than female about banana cultivation. Male get more facilities in banana cultivation. Female cannot join in the field as like as male for social and religious restriction. In case of ethnicity there was very little participation from the *Garo* communities than Bengali speaking communities. In Banana agroforestry practice, highest 75% respondents were Bengali speaking people. Number of literate respondents were 46 [73.33%] and 14 respondents [23.33%] were found illiterate. Among 46 literate respondents, 67.39% were primarily educated, 23.91% were secondary level educated in their life time and 8.67% were higher level. In case of land holdings respondents were divided into five land holdings classes such as respondents having more than 0.2ha of land were classified as large, less than 0.2 ha but greater than 0.15 ha as medium, less than 0.15 ha but greater than 0.10 ha as small, less than 0.10 ha as marginal and rest are landless person. Among the respondents highest 35% respondents were found to have small land holdings followed by 25% are marginal 18.33% respondents are landless and found to live inside the forest building a muddy house, 16.67% are medium and 5% are large. Moreover, among the 60 respondents 48.33% person's primary occupation is agriculture. 21.67% is day labor 16.67% is business. The secondary occupation is business [41.67%] followed by agriculture [23.33%] and day labors [23.33%].

Soil physical and chemical properties

Natural Sal forests of MNP has been converted into plantation forests, woodlots of exotic species, rotational forests, rubber gardens, banana gardens, pineapple orchards, paddy field, and homesteads also for other agricultural crops. Application of fertilizers, pesticides, growth hormones and other chemicals for the better production of banana causing drastic changes in the soil profiles of Madhupur NP. Sal tree is that kind of species which cannot tolerate extreme acidic soil but due to application of these chemicals soil is becoming more acidic. To evaluate the changes of soil physical and chemical properties between banana agroforestry soil and soil of natural Sal forest were tested. Results obtained from soil analysis presented in [Table 2] showed that soil pH condition in banana was 4.62 where in natural Sal forest it was pH 5.03. Average organic matter [OM] content was higher in banana agroforestry soil [2.57%] than Sal forest [2.02%]. Moreover, the content of Nitrogen [N], Phosphorus [P], poatassium [K], Zinc [Zn], Cupper [Cu], Iron [Fe]

and Magnesium [Mg] was highest in banana plantation. Conversely, the amount of moisture content [11.62%] and Sulphur [S] were higher in Sal forest [66.06 µg/g soil]. Changes of soil properties due to indiscriminate application of fertilizers, pesticides and growth hormones, it was observed that coppicing ability of Sal trees were reducing. Farmers concerned about the negative effects of excess use of chemicals on soil but they are ignoring it because they need more banana production as it's their business and they totally depend on banana agroforestry income.

Biological diversity indices of banana based agroforestry and natural Sal forest

Plant species diversity and species richness was very much unsatisfactory in both banana agroforestry and natural Sal forest land uses. The main tree species found in both land uses are dominated Sal [*Shorea robusta*] and the other regular species are Menda [*Litsea monopetala*], Haldu [*Adina cordifolia*], Koroi [*Albizia* spp.], Eucalyptus [*Eucalyptus* spp.], Bahera [*Terminalia belerica*], Hargoja [*Dillenia pentagyna*], Adagash [*Croton oblongifolius*], Sonalu [*Cassia fistula*], Kushum [*Schleichera olosa*], Chattim [*Alstonia scholaris*], Haritaki [*Terminalia chebula*], Shewra [*Streblus asper*], Shimul [*Bombax ceiba*], Amloki [*Phyllanthus emblica*], Depha jam [*Cleistocalyx operculatus*] etc. As an undergrowth Bashak [*Adhatoda vasica*], Assamlata [*Eupatorium odoratum*], Pepe [*Carica papaya*], Bon-ukra [*Urena lobata*], Bon-begun [*Solanum nigrum*], Vat pata [*Clerodendrum infortunatum*], Sim [*Dolichos lablab*] Man kachu [*Alocasia indica*], Shatomuli [*Asparagus racemosus*], Kancha kola [*Musa paradisiace*], Thankuni [*Centella asiatica*] were the most dominant species. The result of Shannon-Winner diversity index [H] was found highest for tree [3.02], herb [2.72], and shrub [2.45] species in natural Sal forest. Similarly, the result of Species richness index [R] was calculated highest also for tree [3.33], herb [2.42], and shrub [1.88] species in natural Sal forest. Species diversity index [SDI] was calculated the highest for both herb [0.04] and shrub [0.07] species in banana agroforestry land use than Sal forest [0.03] for each. However, the value of Simpson index was found higher for tree, herb and shrub in banana agroforestry land use than that of Sal forest and Species evenness index was found higher for tree species [2.28] in banana based agroforestry land use and for herb species highest [2.26] in Natural Sal forest [Table 3]. Study findings represent that number of trees, herbs and shrubs were more in Sal forest than banana agroforestry land use. The results indicated that the diversity, richness and evenness status of species in two land uses were inadequate also specify that it is a matter of great concern that if the conversion of Sal forest to different types of land uses goes, the forest will no remain more Sal trees along with other natural regenerated species.

Benefits and drawbacks of banana based agroforestry system

Peoples of the study area are being benefitted by banana based agroforestry system but it has some negative impacts of on forest soil and biodiversity. About 25 to 27% of the encroached natural Sal forest area is under banana cultivation. Banana cultivation occupied second position among other different land uses. A semi-structured questionnaire was used among the farmers to find out their views on both benefits and drawbacks of banana agroforestry system. Table 4 represents the major benefits and drawbacks of banana based agroforestry system. Approximately 68.33% of the respondents noticed that banana agroforestry system reduce pressure on natural Sal forest while 55% noticed that it ensure maximum and quick return. While 48.33% respondents reported that this system has higher employment opportunity followed by 46.67% believed that products have huge market demand round the year, these are the main benefits. Conversely the main drawbacks of this system reported by the respondents includes, soil erosion [51.67%] followed by lack of Sal coppicing [38.33], land tenure problem and biodiversity loss [35% each], etc.

The growing human population, their extreme pressure on natural resources and lack of knowledge about ecological balance of nature, destroyed our surrounding environment in such a manner that there is already a vast degradation of soil, water, air, biodiversity. Forest is an inseparable part of our environment; it maintains ecological balance and also plays important role in national economy of a country. As, Bangladesh is one of the most densely populated country in the world here population pressure is so much high on the major and minor forest products, for food, fuel wood, fodder, shelter, construction materials, etc. Other causes of forest degradation are expansion of agriculture, road construction, industrialization and urbanization.

MNP has a high socio-economical and ecological importance for the central part of Bangladesh but this forest is degraded extensively day by day. The extensive degradation of this forest resources

and reduction in forest area reported in the Forestry Master Plan [16], Forestry Sector Project, other documents and maps. Nearly all mature trees have been removed for agricultural and settlement uses, pineapple, banana and lemon based agroforestry, and industrialization with the result that little or no mature natural Sal forest remains. MNP is harshly impacted by deforestation, fuel wood collection particularly excessive litter collection, over exploitation, encroachment, indiscriminate collection of economically important plant species [i.e. medicinal, fodder etc], and other forms of human interference [36, 40]. Natural Sal forest is also endangered due to the shifting cultivation practices and introduction of exotic species into forest through plantation programme by the Forest Department [12]. The destruction of natural ecosystems of Sal forest goes hand in hand with a drastic reduction of biodiversity, which hampers the quality of life as well as economic development. The massive destructions of Sal forests of Bangladesh coincided with our limited knowledge on the composition, species richness, structure, regeneration pattern [1] compared to India and Nepal. To prevent encroachment and degradation of Sal forest, the forest department was initiated agroforestry programmes. Participants grow agricultural products such as paddy, banana, pineapple, lemon, etc. along with exotic fast growing tree species like *Eucalyptus* spp. and *Acacia* spp. At the same time natural Sal forests were destroyed to raise woodlot plantations with mainly *Eucalyptus* spp. and *Acacia* spp. [19, 2]. As a result, the forests lost their original character due to agriculture and agroforestry practices, which required tillage operations and intercultural operations. Soil properties have also been impacted by indiscriminate use of fertilizers and pesticides. The tillage operations caused impacts on the soil by losing habitat for natural regeneration of trees. The soils are disturbed by digging out stumps, digging ponds, roads construction, daily household activities and other infrastructures, etc. Domestic animals graze on the forest floor causing negative impacts on species number and composition also grazing intensity decreases the fine soil particle content [31]. Both ethnic and Bengali women, little boys and girls professionally involved sweeping forest litter for daily domestic needs also sell it to the local market thus forest soils losses its fertility due to scarcity of organic matter. Farmers also used various fertilizers, pesticide and growth hormones in agroforestry and paddy cultivation, these chemicals have negative impacts on soil fertility.

Although banana based agroforestry is an economically profitable business to the local people but this system fully destroy the soil, water and biodiversity of the surrounding areas. From the survey it was observed that due to banana cultivation wildlife population already been destroyed. Shortage of food, poaching and negligence of duties by the forest department officials are also responsible for the imperilment of wild animals in the forests. Many kinds of wild animals including leopard, wild buffalo, wild cow, wild hog, wild cock, peacock, spotted deer, jackal, wild cat, mongoose, wild goat, red mouth monkey, black mouth baboon, porcupine, squirrel, hare, pangolin, wild cat and bobcat different varieties of birds, reptiles and snakes, etc. were seen everywhere in MNP only two to three decades ago, said by ethnic residents of Madhupur. But at present, leopard, wild buffalo, wild cow, wild hog, peacock, wild goat, porcupine, hare and pangolin have already lost and forests due to over-exploitation, encroachment of forestlands, use of forestlands for rubber gardening, raising fruit orchards, practices shifting cultivation and various agroforestry systems and poaching by a section of local residents. Often some wild animals were moving near inhabited areas due to shortage of their foods in forests. Many birds including hawk, peacocks, mynah, nightingale, and parrot and snakes pythons and cobras, were seldom found. Besides, a variety of environment friendly worms, ants, butterflies and honey bees have been lost due to indiscriminate uses of chemical fertilizers and pesticides on banana and pineapple gardens in to the forests. Biological diversity index results shows that species regeneration status is not also good under the banana based agroforestry land use. Natural Sal coppice system also disturbed due to the banana cultivation. Although agroforestry system was introduced to control illegal poaching, encroachment, habitation but this system has now seemed to be in appropriate due to its faulty use by introducing banana based agroforestry and people are now clearing forest more rapidly by getting support from local head man because of its year round production and higher market demand and low investment cost.

CONCLUSION

A huge amount of chemicals uses are needed to produce banana which is harmful to the environment. Indiscriminate use of fertilizers is

posing serious health hazard to nearby people. Traditional system of forest management has been totally failed to save the forest or forestland and a large number of land are encroached day by day. Effective control of the forests-use activities of the human population has proven difficult using traditional enforcement methods employed by FD, and it is widely recognized that conservation of the Park's biodiversity will not be possible without the tacit cooperation of this human population. In addition, a large number of people enter the Park area periodically to harvest fuel wood and other resources, for their own use but also to supply fuel wood to adjacent urban areas.

In such a condition a new intervention of management was inevitable. It is essential to conserve the biodiversity of Sal forest and reduce the pressure on the Sal forest. People of the area should be made aware about the bad impacts of banana cultivation. Furthermore forest act should be more time demanding and more efficient. So far very limited amount of study has been conducted on these aspects. So, scientific and intensive management studies should be conducted on soil, biodiversity along with environmental impacts of banana cultivation deliberately and separately on Madhupur National Park to save the forest from encroachment, long term income generation. In order to make a model of sustainable land management of this forest following interventions are highly recommended. Clear felling of all exotic trees through time after maturing into merchantable timber size and afforestation and reforestation by early succession Sal species and zoning the forest lands into core, buffer and peripheral zones are three highly recommended steps for stopping the destruction of the forest. Initiating conservation programme at core zone, gap filling by Sal associates, facilitating natural regeneration in adjacent areas of Sal patches and protecting new born seedling or ephemeral from destruction could play important role in the conservation of forest. Supply of alternative fuel sources in the adjacent area, stopping further plantations of exotic species as they adversely affect the natural ecosystem are also the trustworthy steps to reduce the dependency on the forest. Finally, alternative income generation activities should be created to divert those people who involved themselves in banana cultivation through microcredit programme to minimize the tremendous human pressure on forest.

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Table 1: Demographic features of the respondents

Parameters	Description				
Age classification of the respondents	<25	25-35	35-45	45-55	>55
	7	26	19	6	2
Land holdings	Landless	Marginal	Small	Medium	large
	11 (18.33%)	15 (25%)	21 (35%)	10 (16.67%)	3 (5%)
Educational status of the respondents	Illiterate	Primary	Secondary	Higher secondary	
	14	25	17	4	
Occupational status of respondents	Primary Occupation	No. of respondents		Secondary occupation	No. of respondents
	Agriculture	29 (48.33%)		Agriculture	14 (23.33%)
	Business	10 (16.66%)		Business	25 (41.67%)
	Service	2 (3.33%)		Day labor	14 (23.33%)
	Fisherman	2 (3.33%)		FBSSE	2 (3.33%)
	Day labor	13 (21.67%)		Others	5 (8.33%)
	Others	4 (6.66%)		-	-

Table 2. Soil properties under banana based agroforestry and natural Sal forest of Madhupur National Park, Bangladesh

	Land use	
Soil properties	**Banana based agroforestry**	**Natural Sal forest**
Moisture content (%)	8.46	11.62
Organic matter (%)	2.57	2.02
Soil pH	4.6	5.3
Total nitrogen (%)	0.14	0.11
Phosphorous (µg/g soil)	88.08	2.16
Sulphur (µg/g soil)	33.71	66.06
Zinc (µg/g soil)	2.52	0.95
Cupper (µg/g soil)	0.91	0.59
Iron (µg/g soil)	145.1	41.8
Magnesium (µg/g soil)	0.50	0.30
Calcium (µg/g soil)	1.3	1.5
Manganese (meq/100g soil)	126.9	36.87
Potassium (meq/100g soil)	0.47	0.30
Boron (meq/100g soil)	0.41	0.17

Table 3. Biological diversity indices for plant species status of banana based agroforestry and natural Sal forest in the study area

Indices	**Banana based agroforestry**			**Natural Sal forest**		
	Tree	**Herb**	**Shrub**	**Tree**	**Herb**	**Shrub**
No. of species	6	5	5	22	16	12
Shannon-Winner index (H)	1.78	1.55	1.59	3.02	2.72	2.45
Species diversity index (SDI)	0.07	0.04	0.07	0.04	0.03	0.03
Species richness index (R)	1.13	0.84	0.94	3.33	2.42	1.88
Species evenness index (E)	2.28	2.22	2.27	2.25	2.26	2.27
Simpson Index (D)	0.17	0.22	0.21	0.05	0.07	0.09

Table 4. Benefits and drawbacks of banana based agroforestry system

Benefits	No. of respondents*	Drawbacks	No. of respondents
Maximum and quick return	33 (55)	Soil erosion	31 (51.67)
Market demand of the products	28 (46.67)	Biodiversity loss	21 (35)
Proper site utilization	11 (18.33)	Land tenure problem	21 (35)
Low investment cost	10 (16.67)	Less coppicing of Sal	23 (38.33)
Higher employment opportunity	29 (48.33)	Loss of soil fertility	16 (26.67)
Standard livelihood	16 (26.67)	-	-
Reduce pressure on natural forest	41 (68.33)	-	-

*Parenthesis shows the percentage value

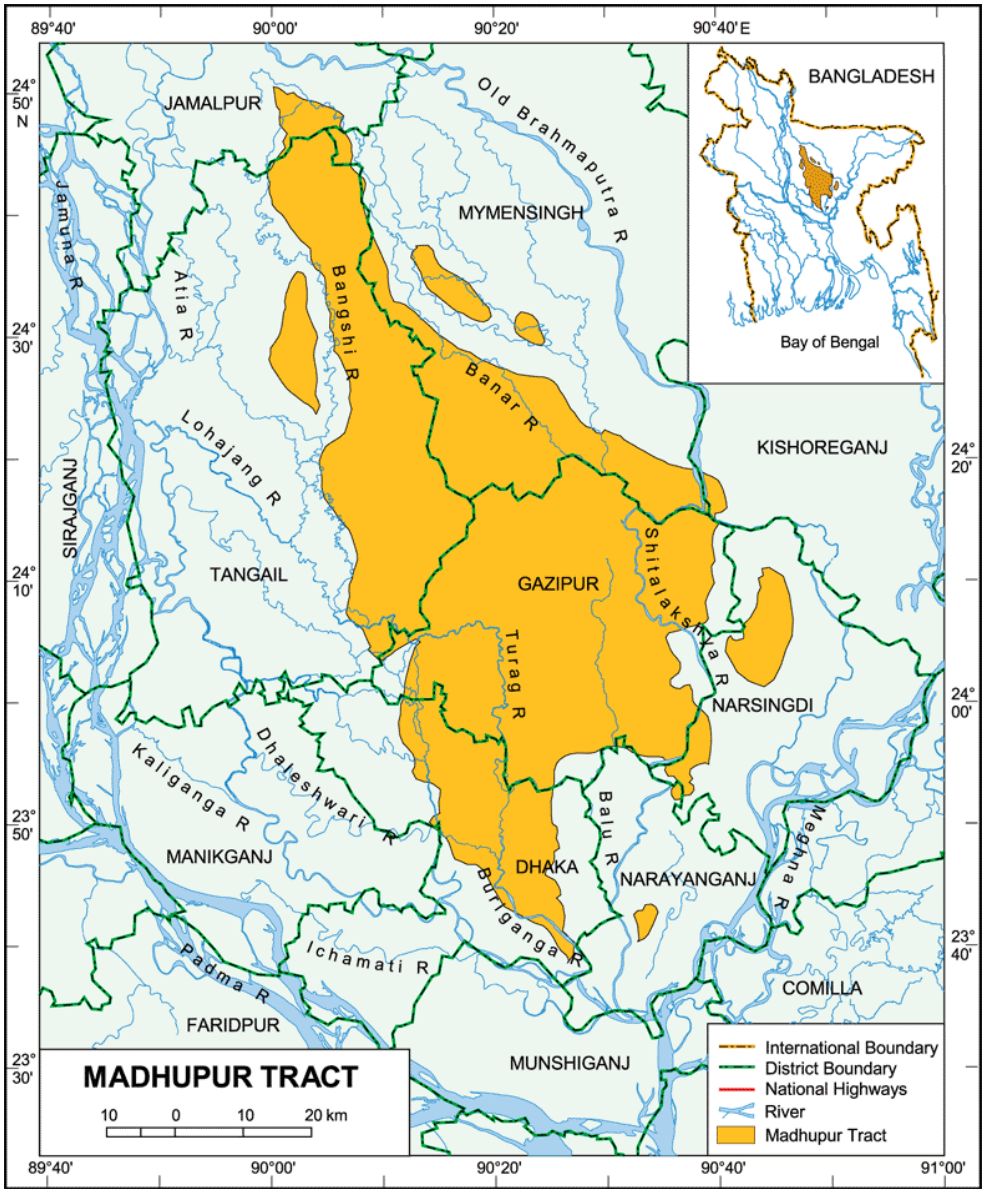

Fig 1. Map of the tropical moist deciduous forest of Madhupur National Park of central Bangladesh (Source: Banglapedia, 2010)