

ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS OF SOCIAL FORESTRY IN THE HIGH BARIND TRACT



A Thesis Submitted in Partial Fulfilment of the
Requirements for the Degree of
Doctor of Philosophy

MOHAMMED NORUL BASHER

Institute of Environmental Science
University of Rajshahi, Rajshahi-6205
Bangladesh

January 2006

DEDICATION

In loving memory of my father:

Mohammed Safar Ali

February 09, 1940 – November 13, 2005

CERTIFICATE

This is to certify that the thesis entitled “**Environmental and Socio-economic Impacts of Social Forestry in the High Barind Tract**” submitted by Mohammed Norul Basher, for the award of the degree of DOCTOR OF PHILOSOPHY is based on the results of investigation carried out by him under my supervision. The thesis or a part thereof has not previously been submitted for any other degree or diploma of this or any other University.

 30.1.2006

(Professor M. Shamsur Rahman)

Department of Botany
University of Rajshahi
Rajshahi

DECLARATION

I declare that this thesis entitled “**Environmental and Socio-economic Impacts of Social Forestry in the High Barind Tract**” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



30/1/2006
Mohammed Norul Basher

ACKNOWLEDGEMENT

First of all I would like to express my deep sense of gratitude to Professor M. Shamsur Rahman, Department of Botany, University of Rajshahi for his proper supervision, guidance, advice, encouragement and assistance throughout the course of this study. I am thankful to Professor M. Sarwar Jahan, Director, Institute of Environmental Science, University of Rajshahi for providing me with necessary supports during the research work.

I must acknowledge the respondents of this study and many people of Godagari, Nachol, and Niamotpur areas, who welcomed me to their truly special homes, gave generously of their time and provided friendships and a learning experience that will be with me always.

I am indebted to Mr. Abdullah al Mahmud and Dr. Md Redwanur Rahman for their thoughtful comments and friendly support. I gratefully acknowledge the useful comments I received from Associate Professor Ashrafuzzaman, Chairman, Department of Social Work, University of Rajshahi.

I wish to express my appreciation to my colleagues and fellow researchers at the Institute of Environmental Science with whom I had useful discussions during the period of this research work. I especially want to thank Mr. Tarekh Rasul, Mr. A.K.M. Munirul Haque, Mr. Ashraful Alam, Mr. Kamrul Ashan, Dr. Mosarraf Hossain, Dr. Kamruzzaman and Mr. Humayun Kabir for their invaluable support during the course of this study.

I also wish to thank the staff of Social Forest Division, Rajshahi, CARITAS, PROSHIKA and Soil Resource Development Institute (SRDI), Rajshahi for their assistance during the field work. The field work would not be such an easy task had it not been for the great help and support I received from Mr. Ashan Habib and Mr. Abu Naser Khan, DFO, Rajshahi Social Forest Division.

I am fortunate to have had the support of a great number of kind and dear relatives, of whom I would particularly like to thank Mr. Abdul Mannan (Khokon), Mr. Arafan Ali, Joint Secretary, GOB and Mr. M. Shahjahan, Director General, Tax Inspection Directorate, GOB.

The financial and material support for this study was obtained from Institute of Environmental Science and University Grants Commission. I very much acknowledge their assistance.

Special thanks to my wife Hasna Pervin for the unfailing support she has bestowed to me and her understanding and patience over the years.

Lastly, this thesis is dedicated to my late father Mohammed Safar Ali who encouraged me to struggle against all odds but did not live to see the attainment.

The author

EXECUTIVE SUMMARY

Social Forestry is one of the policy measures that deals with the environmental restoration and poverty alleviation. Due to encouraging promotion of the government and NGOs Social Forestry has gained momentum in Bangladesh. This study deals with the two related topics: core objectives of Social Forestry (ecological restoration, people's participation and poverty alleviation) and its management practice. (The broad objective of this study was to evaluate the environmental impact as well as socio-economic outcomes of Social Forestry in the High Barind Tract.) Interdisciplinary methods from scientific as well as from socio-economic framework were followed to conduct the study and data from both primary and secondary sources were used. Synecological investigation on the understorey vegetation of two exotic plantation sites (*Dalbergia sissoo* Roxb. and *Acacia auriculiformis* A cunn. ex Benth.) and one native-mixed plantation site (*Terminalia arjuna* (Roxb.) Wt. & Arn + *Mangifera indica* L.) planted under Social Forestry projects and analysis of some major physico-chemical properties of soil of these plantation sites were done. Questionnaire survey was carried out to assess the economic and social outcomes, to analyse management practices and to evaluate the perception of beneficiaries about the impact of Social Forestry on environment. ✓

Content of some soil fertility parameters were found higher in the soils of plantation sites than the soils of their respective non-plantation reference sites, which was indicative of the positive impact of plantation on soil fertility. But this positive impact of plantation was species dependent. The result of t-Test showed significant differences at 5% level between some major soil attributes (Total nitrogen, K and Cu) of the plantation sites and the reference sites.

Majority soil attributes of native-mixed plantation showed the highest percentage of positive changes while that of the soil attributes of *Dalbergia sissoo* Roxb. plantation showed the minimum percentage of positive changes as compared to their respective reference sites. The native-mixed plantation was superior to exotic monocultures- *Acacia auriculiformis* A. Cunn. ex Benth. and *Dalbergia sissoo* Roxb. in enriching the topsoil. Furthermore, the degree of depletion of some soil attributes in the exotic monoculture plantation sites was higher than that of the native-mixed plantation site.

Different analytic and synthetic characters of understorey flora of the three plantation sites were determined by belt transect survey method for a period of two consecutive years. A total number of 57 species of climbers, herbs and shrubs belonging to 25 families were recorded in the three plantation sites during the study period. Among the recorded species, 1 was climber, 41 were herbs, 6 were shrubs and 9 were tree seedlings. In *Dalbergia sissoo* Roxb. plantation site, the total number of understorey plant species was 26; in *Acacia auriculiformis* A. Cunn. ex Benth. plantation site it was 30 and in native-mixed plantation site the total number of species was 42. Among them 9 species were found common in the three sites during the study period. The total number of species and total number of individual plants were found to vary from season to season in all the sites, and were maximum during the rainy season and minimum during the winter season.

As regards the dominance and regular distribution of the species, it was observed that in *Dalbergia sissoo* Roxb. plantation site, *Brachiaria sp* and *Evolvulus nummularius* L. were regularly distributed during the three seasons. In *Acacia auriculiformis* A. Cunn. ex Benth. plantation site, *Oplismenus compositus* (L.) P. Beauv. and *Brachiaria sp* were two dominant species during the rainy season but during the winter season

Cynodon dactylon Pers. and *Evolvulus nummularius* L. gained dominance. In summer season, *Isachne miliacea* Roth. and *Eleusine indica* (L.) Gaertn. were dominant species. In native-mixed plantation site, *Eleusine indica* (L.) Gaertn. and *Evolvulus nummularius* L. were found to be two dominant species during all the three seasons.

The floristic composition of the three sites was distinct from each other and Jaccard's community coefficients were found relatively low among the pairs of the sites. The three sites were in the primary successional state. Presence of naturally regenerated tree seedlings and shrub species were higher in the native-mixed plantation site than the exotic monoculture plantation sites, which indicated that the understorey flora of native-mixed plantation site was at more advanced successional stage than that of exotic monoculture plantation sites. Superior edaphic characteristics and micro-climatic factors of native-mixed plantation site, which were influenced by the overstorey species possibly attributed to this result. The understorey flora of native-mixed plantation site was more diverse and relatively rich in species composition. The result of analysis of variance revealed that the number of species of the three sites showed a significant difference at 5% level in case of sites and seasons. The Shannon's diversity index and evenness index values of understorey flora in the native-mixed plantation site were the highest among the three sites. Findings of synecological survey suggest that the overstorey plantation species influenced the floristic composition and diversity indices of understorey flora. The native-mixed plantation species was more successful in supporting its understorey flora as compared to the exotic monocultures.

The perceptions of the respondents about the impact of Social Forestry were positive in case of temperature, rainfall and prevention of soil erosion while their perceptions were negative in case of soil fertility, biodiversity of different plant groups and native birds.

Majority of the respondents did not get any monetary benefit from Social Forestry projects. A few of the respondents got meagre amount of benefit. Almost all of the respondents hoped that they would get a considerable amount of economic benefit from Social Forestry when the trees would finally be harvested; but the respondents feared that they would not get the rational price of their forest produce, as they were not involved in the extraction, valuation and marketing of the forest produce. However, there was a notable intangible benefit of Social Forestry. It was found that Social Forestry had brought about a positive change of beneficiaries' attitude and thinking towards the improvement of environment. Excessive use of animal dung as cooking fuel suggests that the intervention of Social Forestry towards the lesser use of animal dung as cooking fuel and using it as manure to increase the biomass proportion of soil in the High Barind Tract was ineffective. Fuelwood supply from the Social Forestry projects was insignificant, which implied that Social Forestry projects in the study area failed to fulfil their much-hyped assignment- the 'Fuelwood supply'. The beneficiaries put priorities to their economic benefit and environmental restoration of the area over fuelwood supply as a cause of joining the Social Forestry projects.

As pointed out by the respondents and local people, the ineffective role of Bangladesh Forest Department and NGO officials hindered the proper beneficiary selection. A patron-client relationship was found between the elite selectors and the beneficiaries in the Forest Department-sponsored Social Forestry projects. In case of NGO-sponsored Social Forestry projects, all of the beneficiaries were selected from the target groups of respective NGOs. Therefore, the neediest segment of the people of the communities was virtually left out from the Social Forestry projects in the study area. About half of the female respondents did not take active part in Social Forestry projects. Beneficiaries had little to say about species selection and species

composition. The Forest Department and NGOs took all the major decisions regarding species composition and silvicultural practices. The respondents identified less economic benefit, theft of trees, no arrangement of timely thinning-pruning of plantations and harvesting of forest produce, and lack of co-operation from the Forest Department and NGO staffs as the major constraints of Social Forestry. Most of the species as suggested for future Social Forestry projects by the respondents were native tree species suitable for multipurpose usages including food, medicine, fuelwood, fodder and species of other economic values.

From this environmental and socio-economic research work on Social Forestry in the High Barind Tract, it is obvious that major soil nutrients were at higher levels under plantation sites as compared to their non-plantation sites. Among the plantation sites, the soil of native-mixed plantation site was superior to exotic monoculture ones. Moreover the understorey flora was found more successful in the native-mixed plantation site. From the socio-economic aspect, it has become evident that the preference of respondents to some selected native tree species was not for fuel alone; but they rather preferred these native species for quick and considerable economic returns along with other multiple benefits.

TABLE OF CONTENTS

EXECUTIVE SUMMARY.....	VI
LIST OF TABLES.....	XIV
LIST OF FIGURES.....	XVIII
LIST OF APPENDICES.....	XIX
LIST OF ACRONYMS.....	XX
CHAPTER I: INTRODUCTION.....	1
1.1 Bangladesh Forestry Sector.....	2
1.1.1 Forest Management during Colonial Period	3
1.1.2 Forest Management during Pakistan Period.....	6
1.1.3 Forest Management in Bangladesh and Inception of Social Forestry.....	7
1.2 The Backdrop of the Study.....	12
1.3 The Rationale and the Research Problems of the Study.....	15
1.4 Research Objectives and Questions.....	18
1.4.1 Research Objectives.....	18
1.4.2 Research questions.....	18
1.5 Scope of the Study.....	19
1.6 Overview of Thesis.....	19
CHAPTER II : DESCRIPTION OF STUDY AREA.....	21
2.1 Barind Tract: An Overview.....	21
2.2 Bio-Physical Environment of the Study Area.....	23
2.2.1 Location.....	23
2.2.2 Climate.....	25

2.2.3 Water Sources.....	25
2.2.4 Physiography and Soil.....	26
2.2.5 Vegetation.....	27
2.3 Socio-economic Conditions.....	28
2.3.1 Population.....	28
2.3.2 Transport and Communication.....	30
2.3.3 Occupation of Household Heads.....	30
2.3.4 Land use and Cropping Pattern.....	31
2.4 Social Forestry and Afforestation.....	32
CHAPTER III: MATERIALS AND METHODS.....	35
3.1 Study Methods for Environmental Impacts.....	35
3.1.1 Synecological study.....	35
3.1.2 Soil Sample Collection and Analysis Methods.....	42
3.1.3 Techniques of Analysis of Data.....	43
3.2 Social Study.....	44
3.2.1 Questionnaire Survey.....	44
CHAPTER IV : STUDY OF ENVIRONMENTAL IMPACTS.....	47
4.1 Introduction.....	47
4.2 Results.....	49
4.2.1 Effect of Plantation on Soil Properties.....	49
4.2.2 Comparison of Effects Caused by Exotic and Native-mixed Plantations on Soil Properties.....	50
4.2.3 Floristic Composition and Distribution of Understorey Flora.....	52
4.2.4 Phytodiversity.....	65
4.2.5 Statistical Analysis of Edaphic and Phytosocial Variables.....	66
4.2.6 Beneficiaries' Perception about Environmental Impacts of Social Forestry...	67

4.3 Discussion.....	73
4.3.1 Effect of Plantation on Soil Properties.....	73
4.3.2 Comparison of Effects Caused by Exotic and Native-mixed Plantations on Soil Properties....	74
4.3.3 Floristic Composition.....	76
4.3.4 Phytodiversity.....	81
4.3.5 Beneficiaries' Perception Regarding Environmental Impacts of Social Forestry.....	82
CHAPTER V: SOCIO-ECONOMIC IMPACTS AND MANAGEMENT	
ASPECTS OF SOCIAL FORESTRY.....	100
5.1 Introduction.....	100
5.2 Results.....	101
5.2.1 Socio-economic Background of the Respondents.....	101
5.2.2 Socio-economic Benefits from Social Forestry.....	109
5.2.3 Management Aspects of Social Forestry.....	116
5.3 Discussion.....	123
5.3.1 Socio-economic Benefits of Social Forestry.....	123
5.3.2 Management Aspects of Social Forestry.....	126
CHAPTER VI: CONCLUTIONS AND RECOMMENDATIONS.....	132
6.1 Conclusions.....	132
6.2 Recommendations.....	136
6.3 Recommendations for Further Research.....	137
REFERENCES.....	138
APPENDICES.....	150

LIST OF TABLES

TABLE NO		PAGE
Table 2.1	Population Statistics of the Study Area	29
Table 2.2	Occupational Status of Household Heads	31
Table 2.3	Land use of the Study Area (area in acre)	32
Table 3.1	Number of Local Community Organisations in the Study Area Involved in Social Forestry from 1983/84 to 1996/97	46
Table 3.2	Distribution of Respondents by Organisation and Upazila	46
Table 4.1	Physico-chemical Characteristics of Plantation soils and Non-Plantation soils	50
Table 4.2	Changes of Soil Parameters (%) of Three Plantation Sites in Relation to their Respective Reference Sites	52
Table 4.3	Distribution of Understorey Plant Species in Three Sites During Study Period	53
Table 4.4	Jaccard's Community Co-efficient (%) between the Pairs of Understorey Plant Communities of Three Plantation Sites	65
Table 4.5	Phytodiversity of Understorey Plant Communities of Three Sites during Study Period	66
Table 4.6	Respondents' Perception about Impacts of Social Forestry on Diversity of Different Plant Groups	71
Table 4.7a	List of Species with their Number, Frequency, Density and Abundance Values in Site-A (<i>Dalbergia sissoo</i> Roxb. Plantation Stand) during Rainy Season (July- October 2003 & 2004)	83
Table 4.7b	List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-A (<i>Dalbergia sissoo</i> Roxb. Plantation Stand) during Rainy Season (July- October 2003 & 2004)	84
Table 4.8a	List of Species with their Number, Frequency, Density and Abundance Values in Site-A (<i>Dalbergia sissoo</i> Roxb. Plantation Stand) during Winter Season (November-February 2003-2004 & 2004-2005)	85

Table 4.8b	List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-A (<i>Dalbergia sissoo</i> Roxb. Plantation Stand) during Winter Season (November- February 2003-2004 & 2004-2005)	85
Table 4.9a	List of Species with their Number, Frequency, Density and Abundance Values in Site-A (<i>Dalbergia sissoo</i> Roxb. Plantation Stand) during Summer Season (March- June 2004 & 2005)	86
Table 4.9b	List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-A (<i>Dalbergia sissoo</i> Roxb. Plantation Stand) during Summer Season (March- June 2004, & 2005)	87
Table 4.10a	List of Species with their Number, Frequency, Density and Abundance Values in Site-B (<i>Acacia auriculiformis</i> A cunn. ex Benth. Plantation Stand) during Rainy Season (July- October, 2003 & 2004)	88
Table 4.10b	List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-B (<i>Acacia auriculiformis</i> A cunn. ex Benth. Plantation Stand) during Rainy Season (July- October 2003 & 2004)	89
Table 4.11a	List of Species with their Number, Frequency, Density and Abundance Values in Site-B (<i>Acacia auriculiformis</i> A cunn. ex Benth. Plantation Stand) during Winter Season (November- February 2003-2004 & 2004-2005)	90
Table 4.11b	List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-B (<i>Acacia auriculiformis</i> A cunn. ex Benth. Plantation Stand) during Winter Season (November- February, 2003-2004, & 2004-2005)	91
Table 4.12a	List of Species with their Number, Frequency, Density and Abundance Values in Site-B (<i>Acacia auriculiformis</i> A cunn. ex Benth. Plantation Stand) during Summer Season (March- June 2004 & 2005)	92
Table 4.12b	List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-B (<i>Acacia auriculiformis</i> A cunn. ex Benth. Plantation Stand) during Summer Season (March- June 2004 & 2005)	93
Table 4.13a	List of Species with their Number, Frequency, Density and Abundance Values in Site-C (Native-mixed Plantation Stand) during Rainy Season (July- October 2003 & 2004)	94

Table 4.13b	List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-C (Native-mixed Plantation Stand) during Rainy Season (July- October 2003 & 2004)	95
Table 4.14a	List of Species with their Number, Frequency, Density and Abundance Values in Site-C (Native-mixed Plantation Stand) during Winter Season (November- February 2003-2004 & 2004-2005)	96
Table 4.14b	List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-C (Native-mixed Plantation Stand) during Winter Season (February- November 2003-2004 & 2004-2005)	97
Table 4.15a	List of Species with their Number, Frequency, Density and Abundance Values in Site-C (Native-mixed Plantation Stand) during Summer Season (March- June 2004 & 2005)	98
Table 4.15b	List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-C (Native-mixed Plantation Stand) during Summer Season (March- June 2004, 2005)	99
Table 5.1	Distribution of Respondents by Gender and Age	101
Table 5.2	Correlation between Land Ownership and Economic Conditions of Respondents	103
Table 5.3	Land Holding Pattern of Respondents	104
Table 5.4	Educational Status of Respondents	104
Table 5.5	Economic Conditions of Respondents	105
Table-5.6	Principal Occupations of Respondents	106
Table 5.7	Secondary Occupations of Respondents	107
Table 5.8	Fuel Use Pattern in the HBT (Godagari upazila) in 1991	107
Table 5.9	Respondents' Household Fuel Usage	108
Table 5.10	Economic Benefit from Social Forestry	110
Table 5.11	Expected Monetary Benefit from Social Forestry	111

Table-5.12	Opinion of Respondents about Getting Fair Price of Forest Produce	111
Table 5.13	Ranking of Major Intangible Benefits Derived from Social Forestry	113
Table 5.14	Respondents' Feeling about Fuelwood Scarcity	114
Table-5.15	Contribution of Social Forestry to the Beneficiaries' Annual Fuelwood Consumption	115
Table-5.16	Respondents' Priority to Join in Social Forestry	116
Table 5.17	Selection Process of Beneficiary in Social Forestry projects	117
Table-5.18	Involvement of Woman Beneficiaries in Social Forestry	118
Table 5.19	Distribution of Respondents by Training Obtained	119
Table 5.20	Respondents' Participation in Species Selection	119
Table 5.21	Species Combination of Respondents' Social Forestry Areas	120
Table 5.22	Constraints of Social Forestry	121
Table 5.23	Suggestions of Respondents for Productive Social Forestry	122

LIST OF FIGURES

Figure 1.1	Forest areas of Bangladesh by different years	8
Figure 2.1	Map of the study area	24
Figure 3.1	Map showing synecological study sites within the study area	36
Figure 3.2	Photographs showing synecological study sites	37
Figure 3.3	Species: area curve	38
Figure 4.1	Changes of soil parameters (%) of three plantation sites in relation to their respective reference sites	51
Figure 4.2	Respondents' perception about impacts of Social Forestry on soil fertility and prevention of soil erosion	68
Figure 4.3	Respondents' perception about impact of Social Forestry on temperature	69
Figure 4.4	Respondents' perception about impact of Social Forestry on rainfall	70
Figure 4.5	Respondents' perception about impacts of Social Forestry on number and diversity of birds	72
Figure 5.1	Distribution of respondents by religion	102

LIST OF APPENDICES

Appendix A	Forest Areas of Bangladesh by Different Years	150
Appendix B	Precipitation Data of Three BWDB Observation Stations in the Study Area	151
Appendix C	Afforestation by Bangladesh Forest Department and BMDA in the Study Area	152
Appendix D	Results of t-Test Comparing Differences in Soil Attributes of PSs and NPSs of Three Sites	153
Appendix E	List of Plant Species as Recorded in Three Sites during Study Period (July 2003-June 2005)	155
Appendix F	Phytodiversity of Site A during Study Period (July 2003 To June 2005)	157
Appendix G	Phytodiversity of Site B during Study Period (July 2003 To June 2005)	158
Appendix H	Phytodiversity of Site C during Study Period (July 2003 To June 2005)	159
Appendix I	Results from Two-way ANOVA that Evaluate the Effects of Site and Season on Number of Species and Number of Individual plants	160
Appendix J	Edaphic and other Phytosocial Variables of Three Plantation Sites	161
Appendix K	Correlation Results between Edaphic Factors and Some Phytosocial Parameters as Measured in Three Sites during Study Period	162
Appendix L	Ranking of Preferred Tree Species for Future SF Projects	163
Appendix M	Questionnaire	165

LIST OF ACRONYMS

AD	: Anno Domini
ADB	: Asian Development Bank
ANOVA	: Analysis of Variance
BARC	: Bangladesh Agricultural Research Council
BBS	: Bangladesh Bureau of Statistics
BCAS	: Bangladesh Center for Advance Studies
BFD	: Bangladesh Forest Department
BIADP	: Barind Integrated Area Development Project
BMDA	: Barind Multipurpose Development Authority
BWDB	: Bangladesh Water Development Board
DFO	: Divisional Forest Officer
e.g.	: Exempli gratia/ for example
et al.	: et alii/alia
etc.	: et cetera
FAO	: Food and Agricultural Organization
FD	: Forest Department
FIDC	: Forest Industries Development Corporation
FMP	: Forestry Master Plan
FSP	: Forestry Sector Project
GOB	: Government of Bangladesh
ha.	: Hectare
HBT	: High Barind Tract
i.e.	: id est
IVI	: Importance Value Index
J.C.C	: Jaccard's Community Co-efficient
LCO	: Local Community Organisation
m ³	: Cubic metre
MDB	: Multilateral Development Bank
MOEF	: Ministry of Environment and Forests
MoL	: Ministry of Land

NGO	: Non Government Organization
NPS	: Non Plantation Soil
OM	: Organic Matter
PS	: Plantation Soil
S.E	: Standard Error
SF	: Social Forestry
TANDP	: Thana Afforestation and Nursery Development Project
Tk.	: Taka (Bangladeshi currency)
UNFPA	: United Nations Population Fund
UNO	: United Nations Organization

Chapter One

Introduction

CHAPTER I

INTRODUCTION

Forests and forest produce are the integral part of world's environment and they support the environmental balance of the world as well as supply the major portion of the basic needs of human beings. Forests accommodate a great diversity of largely unknown plants, animals, microorganisms and genes generated by intricate ecological process. Forests and trees provide a range of wood and non-wood products, fuelwood, fruits and vegetables, fodder, medicine and so forth. Forests also provide basic elements for life on earth through ecological functions, regulate climate and water resources, stabilise soil, cycle nutrients, treat waste, provide habitat and facilitate recreation. People began to clear forestlands for agriculture, settlement and grazing from Neolithic age. As the population rapidly increased since the 18th and 19th centuries, a pressure on forestlands also increased. Nowadays the demand for forest goods and resources are the highest ever as the world's population is constantly increasing (Isik, Yaltirik and Akesen, 1997). Population pressure, agriculture, industrialisation and development activities are exerting a tremendous pressure on the forests and forestlands. Forest covers one-third land of this planet (about 3.9 billion hectares) excluding Antarctica and Greenland, which is 29.6% of the world's total Landmass (Larsen, 2003). Assessments have shown that for many years world's forest cover is shrinking. According to Food and Agriculture Organization [FAO] (2003), 0.38% of the world's forest were converted to other land uses (i.e. deforested) every year since 1990s. Although large areas reverted to forest, it leaves a net annual loss of 0.22 percent and the world lost about 94 million hectares of forest from 1990 to 2000.

Bangladesh is a developing country in South-East Asia with low natural resource base but a dense population. The natural resource base of the country is under serious threat, as most natural resources are being over-exploited and used unsustainably. In 1947, the natural forest cover of the country was 24% of the total land (Gain, 1998a), which has now come down to about 5.8% of the total land of the country (Bangladesh Forest Department [BFD], 2003). Bangladesh has nearly 150-years' history of scientific forest management. In the early 1980s, Bangladesh introduced Social Forestry with some core objectives: ecological restoration, poverty alleviation and people's participation. There remains a question whether these objectives are fulfilled at expected level or there is room for a more responsive practice to improve outcomes of Social Forestry. A brief examination of past forest resource management practices and shift in forest policy changes in Bangladesh is essential to fully perceive the answer of this question.

1.1 Bangladesh Forestry Sector

Bangladesh is situated in the north-eastern part of South Asia between 20° 34' and 26° 38' north latitude and between 88° 01' and 92°41' east longitude. The country covers an area of 1, 47,570 sq. km and is bounded by India from the west, north and most of east. Myanmar lies on the southeast and the Bay of Bengal on the south (BBS, 2001a). The country is highly populated and total population of the country is 149.7 million (UNFPA, 2005). Bangladesh is located in a unique geographical location between two biologically diverse sub-regions (Indian and Malayan). Due to this, the country has a number of major natural forest ecosystems including the Sunderban. Forest ecosystems of Bangladesh mainly consist of natural and plantation forests. Tropical wet evergreen, tropical semi evergreen, tropical moist deciduous and tidal

forest ecosystems are in the category of natural forests (Ali, 2003). Plantation forests are however developed in deforested forestlands, degraded hill forests, sal (*Shorea robusta* Gaertn.) forests, marginal lands and newly accreted low-lying coastal areas. Forest area of Bangladesh is gradually decreasing since the independence of Bangladesh. From 1986 to 1996, more than half of the closed forests those were medium to good density forests were turned to either degraded to poor density forests or deforested or encroached (FAO, 2000). Anthropogenic activities and natural causes are the agents of depletion of forest resources in Bangladesh. Increased consumption of forest products, human encroachment, deforestation, illegal logging, low flows in the distributaries of the Ganges due to withdrawal of water at Farakka Barrage point in India during lean season and its consequences are the human induced activities responsible for forest degradation. Climate change, sea level rise also act as natural causes for forest degradation in Bangladesh (Ahamed, Siddiqi & Choudhuri, 1999). Three distinct periods are evident in the forest management history of Bangladesh. They are: 1) Forest management during colonial period 2) Forest management during Pakistan period and 3) Forest management in Bangladesh and inception of Social Forestry.

1.1.1 Forest Management during Colonial Period

The Indian subcontinent was divided into many states that were ruled by different dynasties. No emperor or king was able to unify the Indian subcontinent under a central rule prior to the Mughals. In true sense, Mughals could only unify the Indian subcontinent under central rule. They brought individual states under central control and administrated as federal states during their period (1526-1757). The Mughals were indifferent to forests. During their period reclamation of land for agriculture took place

at a fast pace. They prioritised agriculture over forestry for rapid revenue collection, which caused clearance of forests (Dwivedi, as cited in Mustafa, 2002).

The East India Company usurped the royal power from the Mughals in 1757, which was the beginning of 190 years long rule of East India Company and later the direct British rule in the Indian subcontinent. The British imperial power carried out a fierce onslaught on the subcontinent's forests. Teak timber extraction for shipbuilding and export to England caused large-scale deforestation of Indian forests. "The revenue orientation of colonial land policy also worked towards denudation of forests" (p. 26) commenting about British policy towards forest management Gadgil and Guha (as cited in Divan and Roseneranz, 2001) conclude that the policy towards forest management in Indian subcontinent was aimed at enhancing the revenue earnings from the forests. Promulgation of the Charter of Indian forests in 1855 was the first attempt to conserve forest resources by the British government (Ali, 2003). The Indian imperial forest department was formed in 1864. Dietrich Brandis, a renowned German forester was appointed as first Inspector General of Forests to develop the forest resource management and forest department's organisational set up at that time.

The first forestry related Act was promulgated in 1865 to establish rule of law in the forestry sector. Succeeding the first Indian Forest Act of 1865, a second Act was promulgated in 1878. It was a reformatted document of previous Forest Act. The Act made provisions for three classes of forests: Reserves Forest, Protected Forest and Village Forest. Reserved Forests were earmarked for total state control by a permanent settlement that either wiped out private rights or transferred people elsewhere from the reserved forest areas. In case of protected forests people rights were recorded but not settled. Later on protected forests were gradually converted into reserved forests to exercise the absolute control over these forestlands rather than their precarious status.

Only village forests were open for the local people although the state enjoyed control over regulating the extraction and transit of forest produce (Gadgil and Guha, cited in Divan and Roseneranz, 2001). The Forest Act of 1878 was subsequently amended in 1890, 1901, 1911, 1914, 1918, and 1919. It was largely modified and revised in 1927 and was enacted as the Forest Act 1927 (Act 16 of 1927) but the main essence of the Act was same as the earlier one. Again, the Forest Act 1927 was amended in 1930 and 1933 without substantial changes. The first forest policy for Indian subcontinent was enacted in 1894 and it remained valid throughout the British period. The policy inspired agricultural cultivation in the forestlands and reinforced the state control over forest protection, production and management (Farooque, 1997).

The first attempt of scientific management of Forests was begun in Bengal with the appointment of M.T. Anderson as Conservator of Forests for the lower provinces (Bihar, Orrissa, Bengal and Assam) in 1864. In 1869, an Assistant Conservator of Forests was deputed to earmark the forests suitable for reservation in the Chittagong region. In 1872, Sir Willium Schlich joined as Conservator of Forests of Bengal. He was in charge of five forest divisions namely Coach Bihar, Assam, Dhaka, Chittagong and Bahgalpur. In 1875, the government notified the forests of Sitapahar and Sunderbans as reserved forests under the Forest Act (Act VII of 1865). The Bengal forest division was reorganised in 1876 with the jurisdiction of five forest divisions- Darjeeling, Palamar, Jalpaiguri, Sunderbans and Chittagong (Dwivedi, as cited in Mustafa, 2002). The forests of Sylhet region were notified as reserve forest in 1914 under Assam forest regulation. The Sal (*Shorea robusta* Gaertn.) forests of Dhaka and Tangail regions originally belonged to the local landlords. At the request of respective property owners, the management of Atia forests of Tangail and Mymensingh was taken over by the Government in 1925 and the management of Dhaka forests was taken over in 1934 (Roy, 2000).

1.1.2 Forest Management during Pakistan Period

After the partition of Indian subcontinent in 1947, the forest management objectives in Pakistan remained same as during the British period. Collection of timber by harvesting natural forests was the prime objective of forest management. Attempts were initiated to convert less valuable natural forests to more valuable forest plantations. As a newborn state, the government of Pakistan amended the Forest Act in 1949, which bore the succession of former Forest Act under the British rule. The Act was again amended in 1962 (Farooque, 1997).

The 1894 forest policy was amended in conformity with the requirement of new independent state in 1955. The forest policy of 1955 gave emphasis on revenue earnings from the forestry sector. At that time, clear felling of trees in the forests followed by artificial plantations became a general practice of forest management. In 1962, a new forest policy was framed synchronizing the existing forestry sector development paradigm of the international organisations. To accomplish the development goal and gain the essential capital, tropical forest resources should be extracted rapidly- this concept and notion was spread by western countries and even by FAO in the 1960s. The forest policy of 1962 allowed the liquidation of country's forest resources particularly from East Pakistan (now Bangladesh) to spur the national development. The policy also recommended managing forests intensively as a commercial concern. Keeping the view of the forest policy the then government established Forest Industries Development Corporation (FIDC) in 1960 to carry out extraction of forest produce from remote forests and to develop wood processing and modern wood based industries. In some part of the country (then East Pakistan), FIDC introduced commercial rubber plantations on government forestlands. Forest resource based capital-intensive industries, such as paper mill, board industries and match factories were established in the 1960s under the supervision of FIDC (Pasha, 2003).

1.1.3 Forest Management in Bangladesh and Inception of Social Forestry

After the emergence of Bangladesh in 1971, the Forest Act, which succeeded from Pakistan era, was further amended in 1974. However, the Forest Act of 1927 remained as the template of amended Forest Act (Farooque, 1997). The first National Forest Policy was announced in 1979. The policy was not implemented in its full perspectives except the establishment of a new forest cadre for the management of forestry sector. Due attention on people's participation was avoided in augmenting forest resources which was essential under the changed socio-economic scenario of the country. The main weakness of 1979's forest policy was to treat forestry sector as a government department while some 70 percent of all forest products were produced in the private land (Asia Pacific Forestry Commission, 1998).

In the first half of 1980s, mounting pressures were evident on the forestlands and forest resources of the country due to population pressure, encroachment of forestlands and plundering of forest resources. Pilferage of forest resources and encroachment of forestlands became severe at that time. Poor governance of the Forest Department (FD) and the plundering attitude of people at the helm of state power was largely responsible for forest resources depletion. The 1982 to 1990 regime did the worst in plundering of forest resources. This period recorded the maximum decline of country's forest cover and the highest rate of forest destruction. The total forest area of Bangladesh in 1981-82 was 17.22% of the total land of the country, within a year the forest area declined at 13.67% in 1982-83, which was 20.61% lower than that of the previous year. By 1989-90, the forest area came down to the lowest ever position (12.6%) of the country's total area (Figure 1.1).

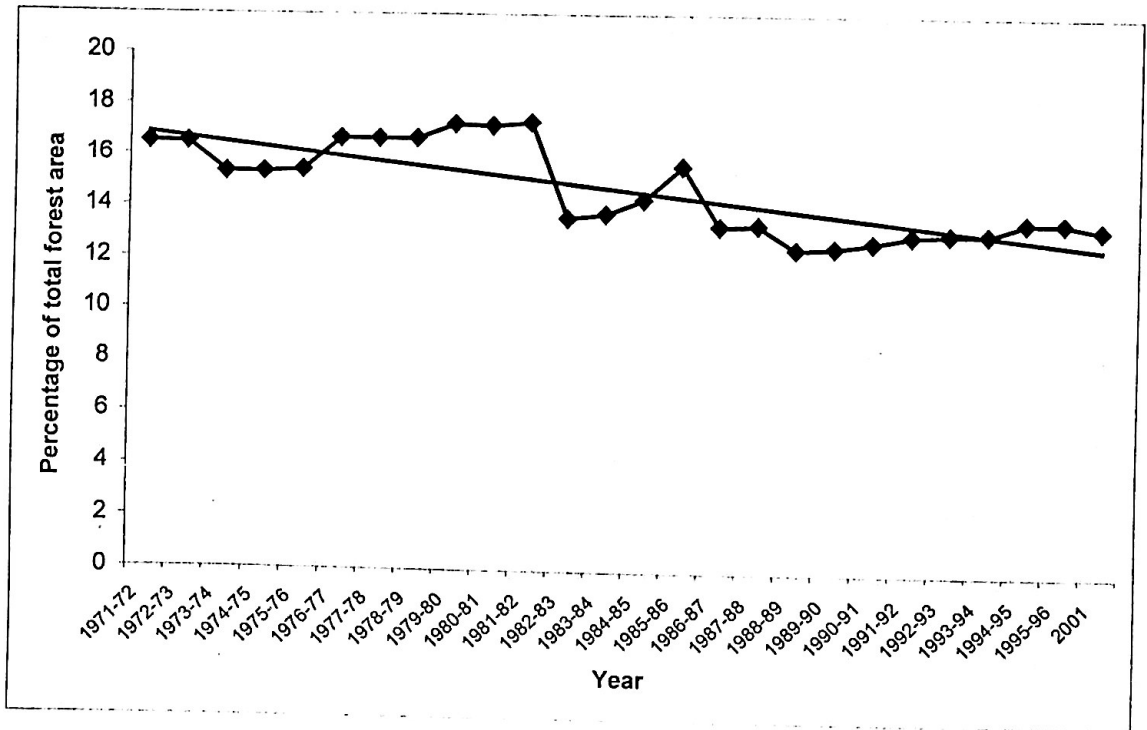


Figure 1.1 Forest areas of Bangladesh by different years

Sources: BBS (1990), BBS (2001b), BBS (2002)

One of the dismal examples of plundering forest resources is Chokoria Sunderbans. Chokoria Sunderbans used to be a reserved and protected forest managed by the FD in Cox's Bazar district (Southeast coastal region of Bangladesh). In 1985, the government decided to hand over all shrimp cultivable forestlands to the Ministry of Land (MoL). The MoL transferred about 7,000 acres of forestland to the Department of Fisheries to facilitate and attract foreign and local entrepreneurs to establish shrimp farm in the mangrove forests (Gain, 1998b). Multilateral Development Banks' (MDB) ambiguous role in the environmental sector also accelerated the environmental deterioration of the country. Slaughtering of Chokoria Sunderbans was done in accomplice of the MDBs while World Bank and Asian Development Bank (ADB) were involved in development of the forestry sector in Bangladesh since 1980. Philip Gain (1998a, p. 44) observes the ambiguous role of the MDBs as: "When World Bank was

supporting regeneration and creation of the mangroves, the same were being destroyed due to prawn cultivation also supported by the World Bank.” In 1976 the mangrove cover of Chokoria Sunderbans was 7500 ha, which was depleted to 973 ha in 1988 and 411 ha in 1999 (Environmental Justice Foundation, 2004).

The current forest policy of Bangladesh was adopted in 1994. The policy was formulated to initiate 20 years Forestry Master Plan (FMP) with a view to enhancing the forestry sector’s ability towards sustainable development. To do so the policy fixed up several core objectives such as stabilisation of environmental condition; poverty alleviation by providing forest-based and other alternative sources of livelihood; and people’s participation through Non Governmental Organisation (NGO) involvement mechanism (Choudhury, 2003).

1.1.3.1 Inception of Social Forestry and Implemented Projects

By the 1980s, massive forest denudation became apparent in Bangladesh. During this period, there was growing acceptance that the century-old protective and policing stance adopted by the governments proved almost ineffective in preventing the pilferage of forest resources. The growing local and international concern towards ‘people-oriented’ forestry provided the momentum for the inception of Social Forestry or Community forestry. Betagi-Pomora Community Forestry Project, the first Social Forestry (SF) programme in the country was started at Betagi and Pomora of Rangunia Upazila under Chittagong district in 1979 and 1980 respectively (Huq and Alim, 1995; Hossain, 2000).

SF in Bangladesh got a real start with the inception of ADB-financed Community Forestry Project in 1982. The project continued for five years in seven greater north-western districts of Bangladesh. The Forest Extension Services (Phase-2)

project began in 1980 funded by the government and subsequently amalgamated in some areas (i.e. North, north-western districts) with Community Forestry Project. The project was implemented from 1980 to 1987 (Huq and Alim 1995; Hossain, 2000). After the completion of ADB-funded Community Forestry Project and government funded Forest Extension Services (Phase-2) project, a follow up project named “Thana Afforestation and Nursery Development Project (TANDP)” was implemented by the FD throughout the country excluding the three hill districts from 1987-88 to 1996-97. The project was financed by ADB. Forest Resource Management Project was implemented in the hill forests of Chittagong, Cox’s Bazar and Sylhet as well as in the coastal districts of the country. ADB-funded “Coastal Green Belt Project” (1995-96 to 2001-02) was implemented in the 12 coastal districts of Bangladesh following participatory approach. Coastal Embankment Rehabilitation Project, a SF project was implemented in the coastal areas from 1996-97 to 2002-03. Forestry Sector Project (FSP), an ADB financed SF project (From 1997-98 to 2005-06) is now being implemented in the 52 districts of Bangladesh (Islam, 2005).

1.1.3.2 Legal Recognition of Social Forestry

After the independence of Bangladesh, the Forest Act was first amended in 1974. It was further amended in 1989 and 2000 AD. The Forest Act of 1989 allowed the government several basic powers largely for conservation and protection of government forests and limited power for private forests. The Act made provisions for establishment of plantation over ‘any government-owned land’ suitable for afforestation. Most of the forestlands under management of the FD were declared reserved and protected under this Act. The Act empowered the government to regulate felling, extraction and transport of forest produce in the country (FAO, 2000). The Act

made provisions to inflict heavier punishment to the forest offenders. The Amended Act was bias towards traditional forest protection rather than accommodation of SF concept. The Forest Act of 1989 was revised in the year 2000, which incorporated SF concept. The section 28A of "The Forest (Amendment) Act 2000" mentions about "Social Forestry" as:

On any land which is the property of the Government or over which the Government has proprietary rights, and on any other land assigned to the Government by voluntary agreement of the owner for the purpose of afforestation, conservation or management through Social Forestry, the Government may establish a Social Forestry programme under sub-section (2)".

Sub-section (2) of the same section further provides

A Social Forestry programme is established when the Government by one or more written agreements assigns rights to forest-produce or rights to use the land, for the purposes of Social Forestry, to persons assisting the Government in the management of the land (Government of Bangladesh [GOB], 2000, pp.1330-31).

The Government has formulated Social Forestry rules entitled " The Social Forestry Rules, 2004" under The Forest (Amendment) Act 2000, which provides a framework of agreements, prescribed forms, and selection criteria of beneficiaries, NGOs and management committees (Islam, 2005). Nowadays SF is no longer confined to the government sector in Bangladesh. NGOs are playing an increasingly effective role in SF. A huge number of national and local NGOs have involved in SF throughout the country. There seems to be convergence between the core objectives of SF and some of the principles of development currently being promoted by NGOs. However, the environmental and socio-economic betterment as a core objective of SF can in fact be realised on the existing ground remains to be demonstrated. It may be determined by examining some theoretical and practical issues concerning the management practices of different SF projects.

Rajshahi University Library
Documentation Section
Document No. D-2586
Date. 13.2.07

1.2 The Backdrop of the Study

In Bangladesh, there has been growing recognition of social equity in association with environmental concerns during formulation of development policies. SF is one of the policy measures that deals with environmental restoration and poverty alleviation. Due to encouraging promotion of the government and NGOs, Social Forestry has gained momentum in Bangladesh. Nowadays it has turned into a social movement. Celebration of tree plantation month, tree fair in different Upazilas (an administrative tier) and district headquarters, prime minister's awards for the achievement in tree plantation etc., bear the evidence of enthusiasm to afforestation and SF in the country. This enthusiasm is the culmination of combined efforts of the government, development workers, Multilateral Development Banks and different donor agencies. This thesis deals with the some *core objectives* of Social Forestry. They are: a) ecological restoration, b) people's participation, and c) poverty alleviation. These objectives manifest the concepts of environmental, social and economic sustainability. This thesis also deals with '*management practice*' of SF. The two topics of SF, i.e. *core objectives* and *management practice* are inextricably interwoven. Sustainability of SF largely depends on proper synchronisation of these topics.

The current national forest policy of Bangladesh (Forest policy of 1994) is considered as one of the progressive policies. It has incorporated the concepts of people's participation or democratisation of access in forest resources, poverty alleviation and restoration of sound ecosystems (Dey, 96; Khan, 2001a; Choudhury, 2003; Hossain, 2003). These concepts endorse the impression of sustainable forest policy. Bangladesh government considers SF as one of the key approaches to achieve the goal of sustainability in the forestry sector. According to the stated declarations of 'Forestry policy 94', the Government has planned to speedy augmentation of 20%

green cover of the total land of the country within the year 2015 and SF is deemed as one of the means to realise the objectives of the forest policy.

Despite such developments, in recent years there exist some controversies on the environmental and socio-economic impacts of SF programmes. Some critics argue that most of the implemented SF projects were slanted towards commercially viable trees (Rahman, 2000; Roy and Halim, 2001). The SF project implementing agencies preferred mostly exotic species for afforestation and established exotic monocultures without considering their impacts on biodiversity, environment and culture of the local people. Friends of the earths- Bangladesh (2003, p.58) criticises harshly such approach as:

Tree-planting, as it is carried out officially in Bangladesh, is neither a road to economic sustainability nor an effective means of carbon sequestration to stabilize the global temperature, now rising day by day due to rich countries' unscrupulous development actions and plans. The "carbon-sink" agenda is a political ploy of Northern countries to keep the concerned world public's eyes off the real problem.

Wright (as cited in Zubel, greet and Stahl, 1981) opines about introduction of exotics as "An exotic should never be used until it has been thoroughly proven by testing in the area in which it is to be grown" (p.9). Rahman (2000) states that alien tree plantations destroy the indigenous vegetation. In an ecosystem, a food chain may have four or five trophic levels through which the energy passes. There may be several food chains in an ecosystem. All the plants and animals are interrelated to one another in these food chains. Exotic species usually disturb the natural energy flow of food chains. As a result, local flora and fauna cannot adapt and develop properly in such plantation. In a study on coastal grassland, Vivrette and Muller (1997) found that species richness was expected to decline in ecosystems when exotic plants were able to exclude most or all other plant species. Moreover, the management practices of the implemented SF

projects were top-heavy instead of the bottom-up management approach. People's participation in true sense was elusive in all stages of these SF projects (Khan and Begum, 1997; Roy and Halim, 2001).

On the other hand, research findings of tropical forests indicate that plantation may facilitate gradual succession and establishment of woody species (Parrotta, 1995; Geldenhuys, 1997; Otsamo, 2000). Parrotta (1995) observes that establishment of plantations act as successional catalysts and can improve a degraded land long devoid of a native tree cover by facilitating re-colonisation of native flora through their influence on understorey microclimate, soil fertility, suppression of dominant grasses and provision of habitats for seed dispersing animals. Some studies suggest that in Bangladesh positive impacts of plantations under SF programmes outweighed the negative ones, especially in case of plantations established on degraded lands (Ali, 1996; Uddin *et al.*, 2000; Mridha, 2002).

1.3 The Rationale and the Research Problems of the Study

Earlier SF projects of Bangladesh were started in the Barind Tract in 1982. The considerations to start SF projects in this tract were the severity of environmental and socio-economic problems. In a report, Mahtab *et al.* (1984) state that the reason behind the selection of north-western part of Bangladesh as priority region for implementation of SF projects were the scantiness of forest cover in the region. The area had only 2% tree cover, the lowest in the country at that time and that was resulting in substantial deficit of fuel wood, construction timber and other tree products. The location of the Barind Tract is in the north-western part of Bangladesh spreading over an area of 7,728 km² (Ministry of Environment and Forest [MOEF], 1997). Barind Tract is an ecologically fragile zone of the country. Intensive agricultural expansion and other anthropogenic activities have already squeezed the natural vegetation of the tract. According to various reports, the environmental conditions of this area are further aggravating due to aggressive exploitation of remaining available biomass, including crop residue and animal dung. The loss of biomass has direct effect on soil fertility, which is diminishing the cycling of organic matter on the soil (Zuberi, 1998; MOEF, 2000; MOEF, 2002). The area is completely in lack of any sources of extensive energy production e.g. natural gas, electricity and forest coverage. Therefore, people depend on available biomass such as animal dung and crop residue to meet up their daily cooking fuel requirement. The impact of biomass shortage is severe in the Barind Tract. For instance, in 1993 the fuel wood demand was 2,008,000m³/annum and the supply was only 882m³/annum in the north-western districts; as per consumption trend the demand of fuelwood will be 2,804,000m³/annum and supply will be 1300m³/annum in 2013 (MOEF, 1993).

The consequences of over exploitation of biomass are acceleration of water and wind erosion of the topsoil with additional effect of large-scale deforestation. The Barind Tract once rich with vegetation cover is now showing symptoms of desertification due to over exploitation of biomass in large scale (MOEF, 2000). Agro-ecologically the Barind Tract is divided into three regions: Level Barind Tract, North-eastern Barind Tract and High Barind Tract. Bangladesh Agricultural Research Council (BARC) places the High Barind Tract in the Agro-ecological Zone no-26 (Karim and Iqbal, 2001). Due to environmental adversity and climatic extremity, Barind Multipurpose Development Authority (BMDA) (as cited in MOEF, 2002) ranks the High Barind Tract as the most environmentally vulnerable area of the Barind Tract. The land degradation map prepared by Space Research and Remote Sensing Organisation from satellite imagery shows the symptoms of degradation process of natural resources in Nachol area of the High Barind Tract. Water erosion, loss of top soil, physical and chemical deterioration of soil, surface scaling and crusting, and soil compactions are evident in the area (MOEF, 2002).

Against the backdrop of such environmental situation of the tract, government organisations (FD, BMDA) and NGOs have been implementing afforestation programmes since early 1980s under different SF projects aiming at recuperating the deteriorating environmental conditions as well as socio-economic development of the people of the tract. In order to do that the FD and NGOs have extensively planted exotic species generally in the form of monoculture. Sissoo (*Dalbergia sissoo* Roxb.) was planted extensively throughout the area; and in some cases Akasmoni (*Acacia auriculiformis* A. cunn. ex Benth.) and Mehogoni (*Swietenia mahagoni* (L.) Jacq.) were also preferred for plantations. Sissoo was the most preferred plantation species in afforestation in the northern districts of Bangladesh and 80% of the trees planted by

different government organisations and NGOs were Sissoo (*Dalbergia sissoo* Roxb.) (The Independent, 2002). It is increasingly recognised from different parts of the world that the traditional environmental rehabilitation method (i.e. monoculture plantations of exotic species) may not be appropriate in all instances or for all purposes (Struhsaker, 1987). In the High Barind Tract, SF programmes were aimed at ecological restoration as well as socio-economic development for the general mass, especially lower segments of population. To what extent these programmes are successful is not clear to the nation as a whole. Some researchers have tried to evaluate the impacts of SF projects elsewhere in the country. These evaluations were largely focused on the socio-economic aspects and implementation techniques of SF intervention. Impacts of SF intervention on environmental components as well as its socio-economic outcomes have not been sufficiently quantified and evaluated in Bangladesh situation especially in case of the High Barind Tract. Therefore, a comprehensive study is needed to understand the level of success, failures and reasons behind these and to suggest remedial measures of SF programmes. This was the main impetus behind this research. It is hoped that this study will provide more accurate information about the effectiveness of current SF initiatives in Bangladesh and contribute to the debate on the value of SF as a forest resource management, ecological restoration and poverty alleviation strategy in Bangladesh.

1.4 Research Objectives and Questions

The broad objective of this study was to evaluate the environmental impact as well as the socio-economic outcomes from SF. The specific objectives and research questions of this study were as follows:

1.4.1 Research Objectives

- 1) To measure the impact of extended afforestation programmes on some soil properties.
- 2) To determine the species composition, qualitative characters and phytodiversity of the understorey flora in the exotic and native plantation sites planted under Social Forestry projects.
- 3) To evaluate the perception of beneficiaries about the impact of afforestation on some environmental parameters.
- 4) To assess the economic and social outcomes of Social Forestry.
- 5) To analyse the management practices of Social Forestry programmes.

1.4.2 Research questions

In order to accomplish these objectives and to create guidelines for collecting essential data, the following research questions were formulated:

- 1) What is the effect of plantation on soil fertility?
- 2) Does soil fertility differ in relation to exotic and native plantation species?
- 3) Do the overstorey plantation species have impacts on understorey species composition?
- 4) Does understorey phytodiversity differ in relation to exotic and native plantation species?
- 5) What are the perceptions of beneficiaries about the impact of Social Forestry on soil, temperature, rainfall, flora and fauna of the study area?
- 6) What is the extent of economic and social outcomes of Social Forestry?
- 7) What are the management drawbacks of Social Forestry programmes in the study area?

1.5 Scope of the Study

The intention of this study was to assess the environmental and socio-economic impacts of SF programmes in the High Barind Tract implemented by the FD and NGOs over the last two decades. The study was conducted in the three upazilas of the High Barind Tract. They were Godagari of Rajshahi district, Nachol of Chapai Nawabganj district and Niamotpur of Naogaon district. In this study, the term 'Social Forestry' stands for - afforestation activities in public lands with direct participation of community people, where the FD and NGOs act as facilitators of afforestation programmes. Among the various types of SF, Strip plantation and Woodlot plantation-these two were considered for the scope of this research, as these two types of SF were widely implemented by the FD and NGOs in the study area. Beneficiaries who were involved in SF programmes at least for 7 years were selected as the respondents of this study. The harvesting period of different types of trees and intermediary crops in SF could vary. Generally the periods are - one year in case of agri/intermediary crops, 5-7 years in case of fuelwood species and minimum period of 15-20 years in case of timber species (Huq and Alim, 1995). According to different projects' rules, after 3-5 years of plantation, beneficiaries could extract forest produce by thinning and pruning. Therefore, the consideration of 7 years of involvement in SF for the selection of respondents was to sort out the beneficiaries who were supposed to get some benefits from SF projects.

1.6 Overview of Thesis

The remainder of the thesis is organised in five further chapters. Chapter II provides an overview of the study area. It involves the biophysical environment of the study area as well as present socio-economic conditions of the people and focuses on the implemented SF activities as carried out by different development agencies. Chapter III describes the methodology of the study. Chapters IV and Chapter V deal with the objectives of the study. These two chapters report, analyze and evaluate field data. Chapter IV examines the environmental impacts of SF through ecological survey, laboratory experiments and analyses the perception of the beneficiaries about the impact of SF on environmental components. Chapter V evaluates the socio-economic outcomes of SF and analyses the management practices of implemented SF programmes in the study area. Chapter VI provides the conclusions and recommendations of the study. It summarizes the major findings of the study, and then answers the question, what is to be done in case of policy implication.

Chapter Two

Description of Study Area

CHAPTER II

DESCRIPTION OF STUDY AREA

2.1 Barind Tract: An Overview

The term Varendra or Varendri is synonymous with the ancient janapada (state) Pundra or Pundravardhana. *Trikandashesa* an ancient lexicon refers Varendri as an ancient part of Pundravardhana (Chowdhury, 2003). There is also a myth behind the name Barendra. "Indra", the God of rain who controls and distributes rainfall and it comes at his will. If he pleases then rain comes, otherwise there would be no rain. Therefore, 'Bar' (Blessings) and Indra' constitutes the word 'Barindra', which has been changed to Barind (Islam, 1997). Barind in modern usages denotes a tract of comparatively high land spreading over portions of Rajshahi, Dinajpur, Rangpur, Bogra and Maldah (West Bengal, India) regions (Siddiqui, 1976).

In Bangladesh, the Barind Tract comprises of the part of greater Rajshahi, Dinajpur, Rangpur and Bogra regions. It is located roughly in between $24^{\circ} 20'$ and $25^{\circ} 35'$ North latitude and from $88^{\circ} 20'$ to $89^{\circ} 30'$ East longitude. The Barind Tract covers 7728 km^2 of area in western part of Rajshahi division, which is equivalent to one fourth of the total area of Rajshahi division. The Barind Tract is bounded by the Karatoya river to the East, the Mahananda river to the West, and northern bank of the Ganges to the South. The little Jamuna and Atrai flood plains occupy fault troughs that have divided the tract into three main blocks (Ahamed, 2003; MOEF, 1997).

The tract is dome shaped, moderately undulated and its land elevation ranges from 6-12 m. Sprouts from large streams flow across the area. There are short streams of local origin. These streams have made deep channels locally known as 'Kharis'. The

tract is formed by old alluvium of middle Pleistocene age within the Bengal basin. Later on the land slightly raised and compressed to the surrounding area due to tectonic movement (Siddiqui, 1976). The soil contains excess iron, lime, and is red in colour, clayey in texture. The Barind soil is deficient in siliceous matter, as it gets no deposits of sand from floodwater. The soil becomes hard as brick in dry conditions. In wet conditions, it becomes soft and slippery. Irregular concretions (Kankar) of calcareous matter form abundantly due to the separation of the calcareous and ferruginous material of the alluvial deposits (Khan, 2002). The Barind Tract is divided into three regions. They are: Level Barind Tract, North-eastern Barind Tract and High Barind Tract. It is hard to distinguish the areas under each of the types; however, spread of each region may be stated. The Level Barind tract includes parts of Dinajpur, Gaibandha, Joypurhat, Bogra and parts of Naogaon, Natore and Sirajganj districts. North-eastern Barind Tract includes parts of Dinajpur, Gaibandha, Joypurhat and Bogra districts. Finally, the High Barind Tract (HBT) includes the western part of the Barind Tract, where underlying Modhupur clay has been uplifted and cut into deep valleys. The location of the HBT is in greater Rajshahi region that includes Rajshahi, Chapai-Nawabganj and Naogaon districts and covers an area of approximately 1600 km² (MOEF, 1997).

2.2 Bio-Physical Environment of the Study Area

2.2.1 Location

The High Barind Tract (HBT) occupies about 20% of the Barind Tract. The tract has an elevation of up to 40m above sea level and is deeply dissected by valleys. The sides of the valleys have mainly been terraced for paddy cultivation (Brammer, 1996). Hillock peaks are rounded but flat, very gently slopping towards the east gradually increase in width. The HBT is situated between $24^{\circ} 25'$ and $25^{\circ} 10'$ North latitude and from 88° to 89° East longitude (Torquebiau, 1991).

This study was conducted in three upazilas of the HBT (Figure 2.1). They are Godagari upazila of Rajshahi district, Nachol upazila of Chapai-Nawabganj district and Niamotpur upazila of Naogaon district. Godagari upazila is in the west of Rajshahi district that is located from $24^{\circ} 21'$ to $24^{\circ} 36'$ North latitude and $88^{\circ} 18'$ to $88^{\circ} 33'$ East longitude. The total area of this upazila is 476 sq. km including 18 sq. km water bodies and rivers (BARC, 1991). Nachol upazila spreads over north-eastern part of Chapai-Nawabganj district and is located between $24^{\circ} 38'$ and $24^{\circ} 50'$ north latitude and from $88^{\circ} 16'$ to $88^{\circ} 31'$ East longitude. The total area of Nachol upazila is 284 sq. km including 1.3 sq. km, 0.6 sq. km and 1.3 sq. km of ponds, rivers and water bodies respectively (BARC, 1997). Niamotpur upazila is situated in the western part of Naogaon district, spreading over a total of 449 sq. km area including 2.20 sq. km of water bodies and 2.49 sq. km of ponds. This upazila lies between $24^{\circ} 41'$ and $24^{\circ} 59'$ North latitude and from $88^{\circ} 23'$ to $88^{\circ} 40'$ East longitude (BARC, 1998).

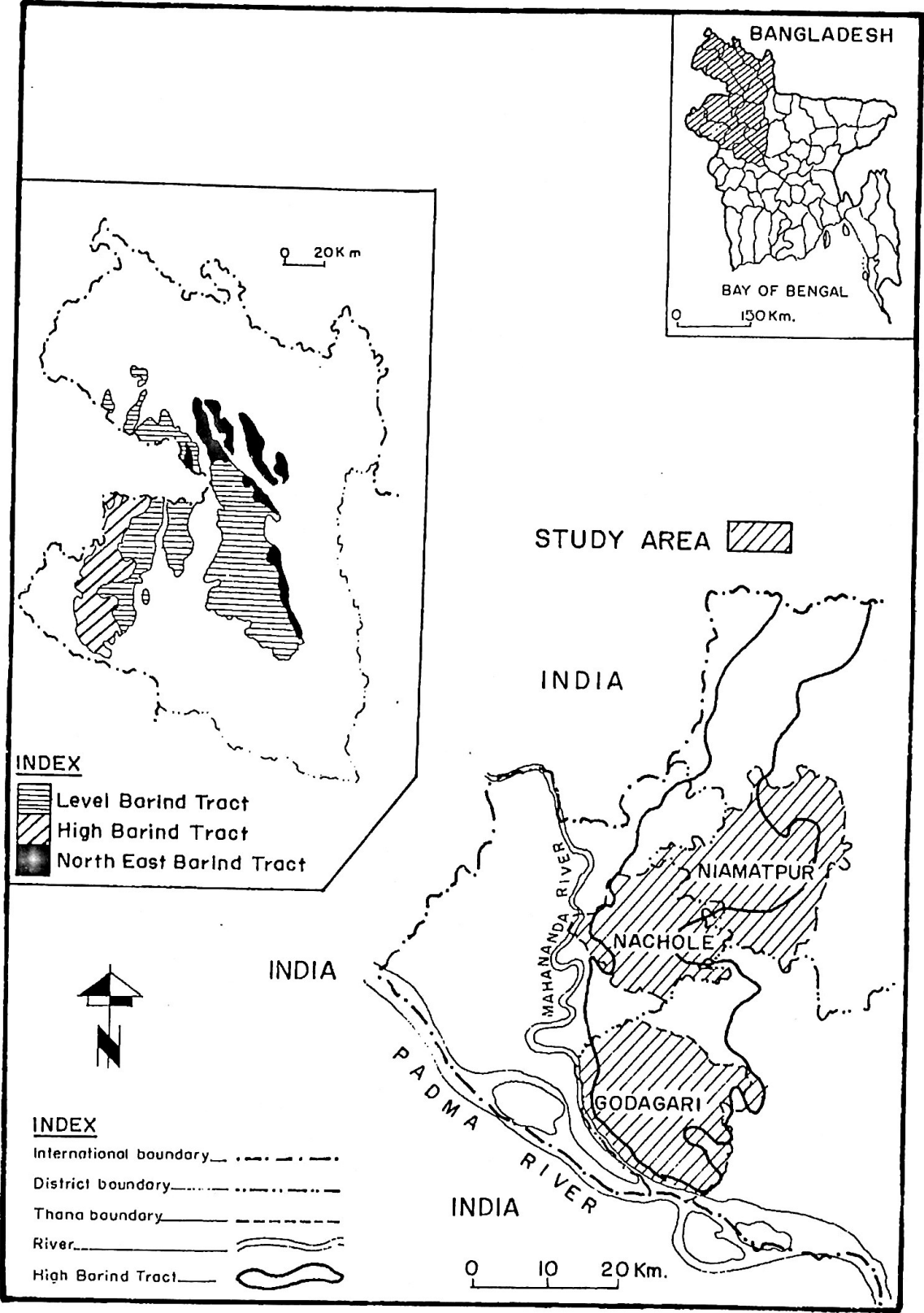


Figure 2.1: Map of the study area

2.2.2 Climate

The HBT lies in the driest part of Bangladesh. The climatic condition of this area is tropical monsoon, like other parts of Bangladesh. Among the six seasons that become visible in Bangladesh, only three seasons are noticeable in the study area. Rainy season lasts from May to October, and 92%, 94% and 91% precipitation occur during the rainy season at Godagari, Nachol and Niamotpur respectively. The winter season starts from November and ends in February. This season is cool and dry; sometimes very little precipitation occurs during this season. March-April is considered as the summer or pre-rainy season. Hot air, scanty water vapour in the air, rain together with gusty wind and hail from the north-west direction are the main characteristics of this season. The temperature in the HBT is considered extreme as compared to the general climatic condition of Bangladesh. The minimum temperature occurs in February ($6-7^{\circ}\text{C}$) and the maximum temperature (45°C) prevails in May (BARC, 1991; BARC, 1997; BARC, 1998). The precipitation records of three observation stations of Bangladesh Water Development Board located at Godagari, Nachol and Manda (adjacent to Niamotpur upazila) show that the mean annual precipitations of these stations were 1416 ± 55.45 mm, 1506 ± 79.32 mm and 1463.35 ± 57.67 mm respectively during the period from 1980 to 2002 (Appendix B). However, long-term data show that the average precipitations during the winter season at Godagari, Nachol and Niamotpur are 46mm, 50 mm and 46mm respectively (BARC, 1991; BARC, 1997; BARC, 1998).

2.2.3 Water Sources

The river Ganges (Padma) flows past the southern periphery of Godagari upazila. The Mahananda River flows past the western periphery of Nachol upazila. These two rivers have contributed to form alluvial land, which is about 9% of the total

land of the study area. Water scarcity is a regular phenomenon in the area, as these two rivers have no prominent tributary network. Ponds, ditches, locally originated short streams (Kharies) and a few low lying areas (beels) are the main sources of surface water. Intense variability of rainfall, longer dry periods, undulating landscape and relatively higher elevations in comparison to surrounding areas have made this region a drought prone area. The ground water quality is good for irrigation and drinking purposes, and is used as major sources of potable water and irrigation. In the recent past, dug-wells were the sources of drinking water; at present, people mainly depend on hand tube-wells for potable water. During the prolonged dry period, the aquifer goes much below the dug-well and hand tube-well levels that causes scarcity of potable water. Recently BMDA is implementing projects intending to supply pure drinking water through construction of overhead tanks and the delivery pipe system in the severely water scarce areas.

2.2.4 Physiography and Soil

The HBT is deeply dissected by valleys. Most of the valleys are without streams. There are two types of lands in the study area: 1) High undulating typical Barind land and 2) Alluvial land. The High undulating typical Barind land constitutes about 91% of the study area (BARC, 1991; BARC, 1997; BARC, 1998). Virtually all the land of the study area is free from normal flood. Old alluvium of middle Pleistocene age has constituted the landform of this area. Later the land was slightly raised and compressed to the surrounding area due to tectonic movement that resulted wide high lands (locally known as Chala) and narrow low lands (locally known as Baid or Kandor). Generally, high lands are 2-4m elevated from low lands (Baid) at Godagari and Niamotpur (BARC, 1991; BARC, 1998) and the elevation reaches the highest (2-5m)

at Nachol area (BARC, 1997). The alluvial land constitutes about 9% of the study area. It is formed by the new alluvial soil of the Ganges at Godagari (14% of the total land), old alluvial soil of the Ganges at Nachol (9% of the total land) and the mixed alluvial soil of the Ganges and the Teesta at Niamotpur (3% of the total land) (BARC, 1991; BARC, 1997; BARC, 1998). Despite the slopping relief, this region has poorly drained grey soil with silty top soil. The soil is relatively compact at a depth of 10-15 cm that inhibits plant root penetration and moisture storage in the soil. The soil colour ranges from grey to mixed grey and brown, and it may change locally ranging from pale brown to red brown. The topsoil texture ranges from silt loam to clay loam and the subsoil texture is mainly clay loam. The soil consistence ranges from hard to extremely hard in dry conditions, friable to firm in moist conditions. The soil becomes sticky and slightly plastic in wet conditions. The topsoil pH ranges from 5.5 to 6.5 that varies locally from 6.5-7. The subsoil pH ranges from 6.5 to 7.5. The organic matter content in the soil is low and the topsoil organic matter ranges from 0.8% to 1.5% that gradually decreases in the subsoil. The HBT's soil is not ideal for plant growth due to low organic matter, and other unfavourable physical and chemical characteristics (Torquebiau, 1991).

2.2.5 Vegetation

The study area is devoid of natural forest but the evidence of the Forest Department's reserve forestlands at Niamotpur points to the existence of natural forest in the recent past. Old records mention that most parts of the Barind Tract were covered with brushwood interspersed with trees (Hunter, 1876). Increasing population pressure has eroded the natural vegetation of the area and converted the land to mostly a cultivable land. The vegetation cover and biodiversity in the HBT are poor. Considerable numbers of herbs, shrubs and aquatic plants grow during the rainy season

in paddy fields, open places, roadsides and ditches. Very few of them can survive in the winter season due to moisture stress and hardness of the soil. The dominant trees in homesteads of the HBT are *Mangifera indica* L. (Amm), *Syzygium cumini* (L.) Skeel, (Jam), *Zizyphus mauritiana* Lamk. (Kool), *Aegle marmelos* (L.) Correa (Beel), *Feronia limonia* L. Sw (Kathbel), *Artocarpus heterophyllus* Lamk. (Kanthal), *Moringa oleifera* Lamk. (Sajina), *Azadirachta indica* A. Juss (Neem), *Albizia lebbek* L. Benth. (Kalokori), *Samanea saman* (Jacq.) Merr. (Phul koro), *Bombax ceiba* L. (Simul), *Acacia nilotica* (L.) Del (Babul), *Diospyros cordifolia* Roxb. (Tamal), *Lannea coromandelica* (Houtt.) Merr. (Jiga), *Erythrina variegata* L. (Mandar) and few other species. *Bambusa sp* (Bans) and some medicinal and non-medicinal shrubs are seen in wastelands around homesteads. Tree species like *Phoenix sylvestris* (L.) Roxb. (Khejur), *Borassus flabellifer* L. (Tal), *Acacia nilotica* (L.) Del (Babul), *Ficus religiosa* L. (Pakur), *Ficus benghalensis* L. (Bot), *Diospyros cordifolia* Roxb. (Tamal), *Trewia polycarpa* Benth. (Pitali), *Delonix regia* (Boj) Raf. (Krishna Chura) are seen in fields, field bunds, pond banks and along roadsides. Exotic tree species have added a new dimension to the vegetation structure of the study area. Extensive plantation of *Dalbergia sissoo* Roxb. sometimes together with *Swietenia mahagoni* (L.) Jacq and *Acacia auriculiformis* A cunn. ex Benth has changed the total vegetation structure of the study area.

2.3 Socio-economic Conditions

2.3.1 Population

The study area had virtually a lesser number of human settlements and was full of bushy jungles in the past. Then different aboriginal groups of people migrated here from the upper catchments of the Ganges. According to Hunter's description: "Immigration mainly by aboriginal or semi aboriginal tribes is carried on from

Rajmahal and western districts of Bengal, principally into the thinly peopled and jungly *thanas* of *Godagari* and *Manda*, the north-west of *Rajshahi* district.” (Hunter, 1876; p.40). In the late 1940s, due to political division of Indian subcontinent a huge number of people were displaced from both the portions of Indian subcontinent. Aftermath of this appalling incident the study area experienced a population boom due to flow of settlers coming from other parts of the subcontinent. This incident changed the composition of the population structure of the area. However, population density in the HBT is comparatively sparse (490/sq.km) as compared to the national (839/sq.km) population density. Table 2.1 represents some basic statistics of population, land ownership and literacy rate of the study area.

Table 2.1: Population Statistics of the Study Area

Parameter	Upazila	Year of Census	
		1991	2001
Population (Person)	Godagari	217811	281640
	Nachol	97119	132440
	Niamotpur	193197	184900
Population density/KM	Godagari	458	592
	Nachol	342	466
	Niamotpur	430	411
Total House hold	Godagari	40011	55880
	Nachol	16940	24540
	Niamotpur	35299	38960
Literacy rate	Godagari	27.60%	41.52%
	Nachol	24.60%	42.22%
	Niamotpur	23.5%	47.75%

Source: BBS (1993), BBS (2003)

2.3.2 Transport and Communication

Only rail and bullock cart were the main communication means in the study area since middle of the 1980s. The introduction of upazila system in 1984 and the national policy to connect every upazila to the national capital of the country brought about the radical changes of communication network of the area. At Present, the three upazilas under this study are well connected with their district headquarters by railroads and metalled roads. Godagari upazila headquarter is situated on the left side of the Rajshahi-Nawabganj Highway. One metalled road connects Nachol upazila via Amnura to the Rajshahi-Nawabganj Highway. Niamotpur upazila is connected to the Rajshahi - Naogaon Highway by a metalled road via Manda. The basic means of transport available for short distances in the study area are rickshaw, rickshaw van, auto rickshaw and cart. The upazila headquarters are connected with most of their Union Parishad (a tier of local govt.) by metalled roads. Bullock carts play a vital role in transportation of agricultural goods during the dry season.

2.3.3 Occupation of Household Heads

The majority people of the study area depend on agriculture for their livelihoods. About 44% dwelling households depend on agriculture. Selling labour to agricultural farm is the second important occupation (33%), while about 7.5% of the households depend on different kinds of business (Table 2.2). In the HBT, a substantial portion of the land is controlled by absentee landlords dwelling at Rajshahi or other cities. Agricultural activities are done by their landless tenants or share croppers. The landless tenants cannot depend fully on the lands they operate for their livelihood round the year. They have to work in others' field as wage labourers. In the HBT Santals and

Orao are the main aboriginal groups who work as wage labourers in the agricultural sector. Aboriginal women also work as wage labourers in different agricultural activities like transplanting of rice seedlings, weeding and harvesting rice and other crops.

Table 2.2: Occupational Status of Household Heads

Upazila	Agriculture	Agri-labour	Wage labour	Commerce	Service	Others
Godagari	36.36%	32.16%	5.35%	11.35%	3.99%	10.89%
Nachol	42.34%	34.11%	3.44%	9.07%	2.80%	8.24%
Niamotpur	54.06%	32.70%	32.70%	2.32%	1.47%	5.43%
Average	44.25%	32.99%	13.83%	7.58%	2.75%	8.19%

Source: (Kaisaruzzaman, 2003; Taru, 2003; Rahman, 2003a)

2.3.4 Land use and Cropping Pattern

Land use is more or less same in the three upazilas under this study. Homesteads occupy 3.75% of the total operated land and about 91.3 % of the total operated land is used for cultivation. BMDA, a government autonomous body has been operating ground water irrigation projects in the area since 1985. Under these projects, hundreds of deep tube-wells have been installed to establish irrigation network for cultivation during the dry season. The irrigation network has changed once rain fed rice monoculture cultivatable lands into triple cropped cultivable lands in some areas. As a result, cropping intensity has increased from 117 to 174 percent in the Barind tract (Rasheed, 2003). Recently BMDA is using the Ganges water for irrigation by carrying water through underground pipelines to Godagari and adjacent areas. Due to these projects, the area under irrigation scheme has increased drastically. In 1983-84, the total area under irrigation was 18.5% of the total cultivable land while the area has increased

to 48.87% in 1996 (Table: 2.3). Before BMDA comes to its operation, rain fed transplanted Amon rice was the dominant crop of the area, and with some exceptions, major portion of the arable lands of the area was under mono-crop cultivation. Irrigation facilities have transformed a large portion of cultivable lands into bi-cropped and in some cases treble-cropped lands. Currently Boro crops and Rabi crops are largely apparent. Main crops of the study area are paddy, wheat, pulses and vegetables etc.

Table 2.3: Land use of the Study Area (area in acre)

	Godagari	Nachol	Niamotpur	Study Area Average
Total operated area	69855	38836	82943	63878.00
Homestead area	2738	1476	2922	2378.67
% of operated area	3.92	3.8	3.52	3.75
Net cultivated area	63488	35607	75663	58252.67
% of operated area	90.89	91.69	91.22	91.27
Irrigated Area, 1983-84	15082	4657	15443	11727.33
% of cultivated area, 1983-84	21.96	13.53	19.97	18.5
Irrigated area, 1996	35896	13916	38559	29457.00
% of cultivated area, 1996	56.56	39.09	50.97	48.87
Crop intensity	134.2	136	133.2	134.47

Source: BBS (2000a), BBS (2000b), BBS (2000c)

2.4 Social Forestry and Afforestation

Severity of environmental problems of the Barind Tract such as aridity, land degradation, ecological imbalances came to the notice of the environmentalists and policy planners of the country in the first half of 1980s. In 1983-84, the FD introduced Community Forestry Development Project in the study area. Concurrently the Ministry of Agriculture introduced Barind Integrated Area Development Project (BIADP) in the fifteen upazilas of Rajshahi region. The objectives of the BIADP (later renamed as Barind Multipurpose Development Authority) were to restore ecological balance,

prevent desertification, and develop living conditions and socio-economic status of the people of the Barind area. BMDA has been working on irrigation, surface water augmentation, communication development and afforestation to materialise its objectives (BMDA, n.da). Extensive afforestation programmes have been implementing in this area through the FD, BMDA and leading NGOs since middle of the 1980s. The implementation mode of the afforestation programmes of these organisations differs from each other. Though there are subtle differences in the implementation and management practices, the FD and the NGO sponsored afforestation projects are SF projects. Involvement of Community people is one of the core components of these SF projects. Forest Department's SF projects have four stakeholders. They are: the FD, Beneficiaries (Community participants), land owning authorities and NGOs. In the FD-sponsored SF Projects, the FD supplies saplings, provides technical support, conducts training for beneficiaries and employs caretakers to look after planting areas for three years while NGOs organise and motivate community people and form beneficiary groups to look after the planting areas until the time of harvest. In the NGO-sponsored SF projects, NGOs, land owning authorities, and beneficiaries are the stakeholders. NGOs form beneficiary groups and provide technical support, training and salary of caretakers. On the other hand, responsibilities of sapling collection and protection of planting area rest on beneficiaries. The afforestation approach of BMDA in the study area is quite different from those of the FD and NGOs. There is no community participation in their afforestation programmes. They employ contactors to supply and plant saplings on roadsides, fallow lands, tank banks and banks of Kharies (Streams). The contractors get their payment according to number of saplings survived in a definite period (Shahidul Islam, Plantation In-charge, BMDA, Personal communication, March 2003). The SF projects, which have so far been implemented in the study area are

mainly strip plantation. The FD has raised some woodlot plantations in degraded forestlands at Niamotpur. Details of afforestation activities carried out by the FD (From 1983-84 to 2001-02) and BMDA (From 1985 to 2002) in the study area are given in the Appendix C. CARITAS and PROSHIKA are the two leading NGOs involved in SF in the study area. The other notable NGOs involved in SF are Asroy, Trinomul, BRAC, TMSS, MAP, SEDIPO, KARIOS etc. These NGOs mainly distribute saplings to their micro-credit groups and motivate them to plant more trees. From 1995-96 to 2001-02, CARITAS afforested 1km roadside and 4 acres of fallow land at Godagari, 8 km roadside at Nachol and 17 km roadside at Niamotpur (Shisir Biswas, Plantation In-Charge, CARITAS, Rajshahi, Personal communication, January 2004). PROSHIKA afforested 125 km roadside at Godagari, 81km roadside at Nachol from 1995-96 to 2001-02 (Prodip Kumar Chakrabarti, Area Co-ordinator, PROSHIKA, Godagari, Personal Communication, January 2004). The on-farm agro-forestry practice is almost absent in the study area. CARITAS is implementing some agroforestry projects besides strip plantations but these projects are not as remarkable as strip plantations. BMDA has planted a total of 1,754,699 saplings from 1985 to 2002 in the three upazilas under this study (Appendix C). *Dalbergia sissoo* Roxb. is the most planted species by the FD, BMDA and NGOs in the study area.

Chapter Three

Materials & Methods

CHAPTER III

MATERIALS AND METHODS

The materials and methods of this research work involved interdisciplinary synergistic approach. It included a synecological study of understorey vegetation of a native-mixed plantation stand and two exotic monoculture plantation stands, analyses of major physico-chemical soil properties of these plantation stands, an assessment of economic and social outcomes of SF, an analysis of management practices of SF and an evaluation of beneficiaries' perception about the impact of SF on environment. Therefore, this study followed interdisciplinary methods from scientific as well as from socio-economic framework. Data from both primary and secondary sources were used to conduct this study. Specific methodologies are discussed in the following sections:

3.1 Study Methods for Environmental Impacts

3.1.1 Synecological study

3.1.1.1 Selection of Synecological study Sites

In the HBT, three plantation stands planted under SF projects were selected as study sites (Figure 3.1 and Figure 3.2). The selected plantation stands were 12-years old and grew under similar climatic and edaphic conditions. For convenience, the plantation stands were named as site A, site B and site C.

Site A: The location of site A is at Kesabpur Mouza of Godagari upazila; 4 km away from upazila headquarter along the Godagari-Kakonhat road. An exotic monoculture plantation stand of *Dalbergia sissoo* Roxb. was selected in this site. The site is situated in the typical High Barind surroundings; i.e. undulating landscape, sparse vegetation with no natural water sources.

Site B: It is located at the Potkoil Mouza of Niamotpur upazila; about 8 km away from upazila headquarter along the Niamotpur to Potkoil feeder road. An exotic monoculture plantation stand of *Acacia auriculiformis* A. Cunn. ex Benth. was selected in this site. The surroundings and the topography of site B are similar to that of site A.

Site C: This site is located at the Gazalbari Mouza of Nachol upazila; 10 km away from upazila headquarter along the Nachol to Mircadanga feeder road. The native-mixed plantation stand comprising of 80% Arjun (*Terminalia arjuna* (Roxb.) Wt. & Arn) and 20% Mango (*Mangifera indica* L.) was selected in this site. The site is situated in the middle of the undulated HBT with deep depressions and valleys.

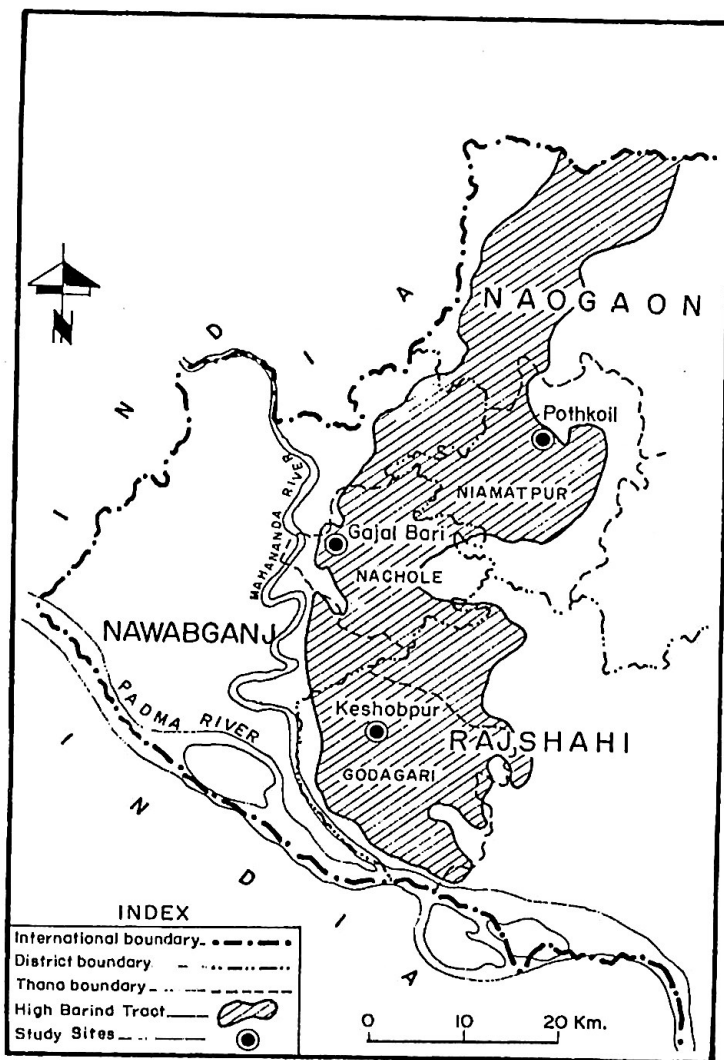


Figure 3.1: Map showing synecological study sites within the study area



Site A



Site B



Site C

Figure 3.2: Photographs showing synecological study sites

3.1.1.2 Determination of Minimal Area

It is essential to determine the appropriate size of the quadrat to be used in any vegetation survey. The quadrat, which is used to sample the plants in a community, must be of such dimensions that all the species, which occurred in that community are fully represented. To determine the minimal area of sample plot/quadrat, different nest plots/quadrats (gradually increased in size) were placed and the number of species found in them were counted and recorded separately. Then the numbers of species found in the plots/quadrats of different sizes were plotted on vertical axis (O-Y) against the gradually increasing plot/quadrat size on the horizontal axis (O-X). The desirable minimal quadrat size was determined by locating a point on the curve where the line took horizontal course and by joining it to the line of axis of quadrat size (Figure 3.3). The joining point indicates the minimal size of the quadrat (Oosting, 1956; Michael, 1984; Shukla and Chandel, 2000). During this study, the determined minimal area was $1\text{m} \times 1\text{m}$ and this size was used throughout the period of investigation.

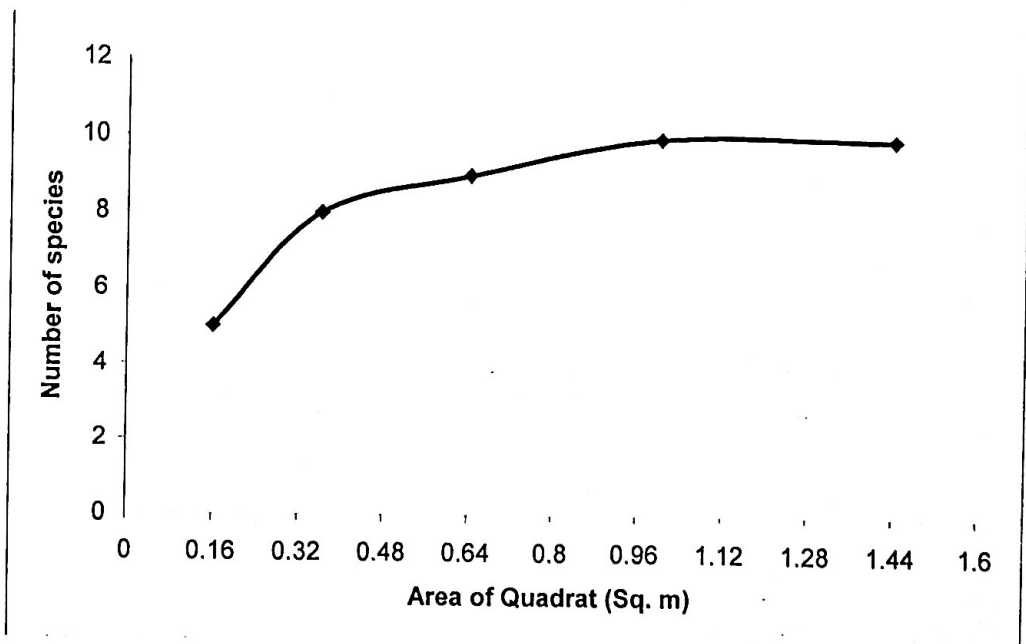


Figure 3.3 Species: area curve

3.1.1.3 Sampling of Vegetation

The three plantation sites as selected for the phytosocial study were strip plantations along the roadsides. Therefore belt transect method was adopted for the sampling of understorey flora. In each site, 5 belt transects were laid. The belts were divided into 10 quadrats each of 1m×1m size touching each other along a straight line. In each of the quadrat, individual number of the tree seedlings, shrubs and herbs belonging to each of the species met with was recorded in the working sheets. Data were collected from all the three sites at regular intervals of four months covering each of the three major seasons- Rainy (July to October), Winter (November to February) and Summer (March-June). As the sites were far away from Rajshahi, sampling on the sites (site A, site C, and site B) were made on 14th, 15th and 16th day of April, August and December in each of the two consecutive years. The vegetation survey was started in August 2003 and was ended in April 2005. The quantitative phyto-sociological characters and the phyto-diversity of understorey vegetation of each plantation site were calculated from the collected data.

3.1.1.4 Treatment of Phyto-sociological Data

Among the phyto-social characters, the quantitative characters of understorey flora of the three plantation sites were calculated from the data as obtained by surveying. There are two sets of quantitative characters, namely analytic and synthetic. In this study, both analytic and synthetic characters were considered.

The analytic phyto-social attributes, namely frequency, relative frequency, density, relative density, abundance and relative abundance values of plant species involved were calculated by using the following formulae:

$$\text{Frequency} = \frac{\text{Number of quadrats in which the species occurred}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of the species concerned}}{\text{Total frequency of all the species}} \times 100$$

$$\text{Density} = \frac{\text{Number of individuals of a species in all the quadrats}}{\text{Total number of quadrats studied}}$$

$$\text{Relative density} = \frac{\text{Density value of the species concerned}}{\text{Total density of all the species}} \times 100$$

$$\text{Abundance} = \frac{\text{Total number of individuals of the species in all the quadrats}}{\text{Number of quadrats where the species occurred}}$$

$$\text{Relative abundance} = \frac{\text{Abundance value of a species}}{\text{Sum of abundance values of all the species}} \times 100$$

The importance value index (IVI) was obtained by adding the values of Relative frequency, Relative density and Relative abundance (Rahman, 2003b; 2005). All species/population of herb and shrub layers were considered together while calculating the IVI values. An importance value index expresses the relative status of different plant population in the community involved. A species with higher (IVI) is considered as the characteristic species of the community.

Among the synthetic characters, Jaccard's Community Co-efficient (J.C.C) was determined by the following formula (Rahman, 2003b; 2005):

$$\text{J.C.C} = \frac{c}{(a + b) - c} \times 100$$

Where,

a= Total number of species in 1st site,

b= Total number of species in 2nd site

c= Number of species common in the pair of communities concerned

The J.C.C value is expressed in percentage that indicates the percentage number of common species between the pair of communities involved.

3.1.1.5 Phytodiversity

Species diversity, evenness, and index of dominance were calculated to compare the diversity, evenness, dominance of the understorey plant communities of the three plantation sites. A phyto-diversity index is a quantitative measure of plant species diversity in a community, which can provides more information about community composition than simply richness. Species richness measures a simple count of the number of species present in an area. But diversity indices take into account the percentage number individuals of different species and evenness or equitability. The Shannon's diversity index (H) is commonly used to characterize the diversity of a community. Shannon's index accounts for both number and evenness of the species present.

The Shannon's diversity index was calculated using the following formula (Odum, 1971):

$$H = - \sum \left(\frac{n_i}{N} \right) \log_e \left(\frac{n_i}{N} \right)$$

$$= - \sum P_i \log_e P_i$$

Where,

n_i = Quantitative value of each species (No. of individual, biomass production and so forth)

N = Total quantitative value; P_i = Probability for each species (n_i/N)

Evenness (e) values of understorey flora of the three plantation sites were calculated by dividing the observed Shannon's diversity index (H) by the value of $\log_e S$. The higher value of (e) means more the evenness.

$$\text{Evenness (e)} = \frac{H}{\log_e S}$$

Where,

H = Shannon's index

S = Total no. of species

For determining the species dominance, the Simpson's index was used. The Simpson index was calculated using following formula (Odum, 1971):

$$\text{Index of dominance} = \sum \left(\frac{n_i}{N} \right)^2$$

Where,

n_i = Phytosocial value for each species (No. of individual)

N = Total of the phytosocial value

3.1.2 Soil Sample Collection and Analysis Methods

3.1.2.1 Soil Sample Collection

To study and compare the impact of exotic and native plantation on soil, soil samples were collected from the three plantation sites, i.e. site A, site B and site C. Soils of non-plantation lands adjacent to the plantation sites were also collected. The non-plantation lands adjacent to the sites were considered as reference or control sites during this investigation. From each of the sites, soil samples were collected from five spots randomly to the plough layer i.e. up to 0-15 cm depth. All the soil samples collected from five spots were mixed together to make a composite sample. By quartering, the bulk was reduced and about 500 gm of the composite sample was retained and was taken to the laboratory. The soil samples were air dried, crushed, mixed well and passed through a 2 mm sieve for chemical analysis. Soil analysis was carried out at the Soil Resource Development Institute (SRDI) laboratory, Shampur, Rajshahi. Some important parameters of the soil samples such as: pH, amounts of Organic Matter (OM), Total Nitrogen, available Calcium (Ca), Potassium (K), Phosphorus (P), Sulphur (S), Boron (B), Manganese (Mn) and Zinc (Zn) were determined in the laboratory.

3.1.2.2 Methods of Soil Analysis

The following standard methods as described by Petersen (2002) were followed for the determination of soil parameters. Soil pH was measured by glass electrode pH meter at a soil: distilled water ratio of 1:2.5. Organic matter of the soil (OM %) was determined volumetrically by Walkley and Black's wet oxidation method. Total nitrogen (TN) in the soil was determined by Micro Kjeldahl digestion method. Phosphorous (P) was determined by Olsen method. Potassium (K) contents of the soil samples were determined directly in the soil extract using a flame photometer. Available Sulphur (S) was extracted by 15% CaCl_2 solution and determined turbidimetrically using $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ and polyvinylpyrrolidone at 535 nm on a spectrophotometer. Calcium (Ca) and Magnesium (Mg) were determined by ammonium acetate extraction method using Atomic Absorption Spectrophotometer (AAS). Zn (Zinc), Cu (Copper), Iron (Fe) and Manganese (Mn) contents of the soils were determined by DTPA (Diethylene triamine pentaacetic acid) extraction method. Boron (B) in the soil was extracted with hot water (0.01M CaCl_2 solution) mixing acetate buffer solution and Azomethine-H reagent with the extract. The absorbance was measured at 420 nm on a spectrophotometer.

3.1.3 Techniques of Analysis of Data

Data of understorey flora and soil attributes were analysed by using statistical methods with the help of MS Excel software. In case of major physico-chemical soil attributes, a t-Test was done between the data of reference soil i.e. Non-Plantation soil (NPS) and Plantation soil (PS). Two-way Analyses of variance (ANOVA) were conducted to evaluate the effect of site and season on the number of individual plants and number of species. Correlation analyses were done to analyse the relationships between edaphic factors and some phytosocial variables of the three sites.

3.2 Social Study

To assess the socio-economic outcomes and to analyse the management practices of Social Forestry in the study area, the methods of questionnaire survey, semi structured interview and personal observation were used. It took a period of 15 months (From October 2003 to December 04) to complete this portion of the study. To overcome information biases and better understanding of the local situation the researcher lived in the study area intermittently during the study period. Both quantitative and qualitative methods were used to collect data pertaining to the socio-economic impacts of SF, management practices of SF and perception of the respondents about the impact of SF on some environmental components.

3.2.1 Questionnaire Survey

Data were collected from the beneficiaries (community participants) using a structured questionnaire. The questionnaire survey opened with questions regarding respondents' present socio-economic status, socio-economic outcomes of SF projects they involved and management practices of some selected SF projects implemented in the study area. The next group of questions concerned with the respondents' perception about the impact of SF on the different components of Environment. Qualitative information were obtained by personal observations and informal discussions with govt. officials, NGO officials, FD & NGO field workers and representatives of the local govt. involved in SF in the study area.

3.2.1.1 Questionnaire Development

The questionnaire was carefully designed keeping in mind the objectives of the study. It contained both open and closed forms of questions. The questions were worded in Bangla language. The questionnaire was pre-tested in the Tanore Upazila adjacent to the study area. Some minor adaptations were included in the questionnaire in the light of the pre-testing to make the data collection work easy.

3.2.1.2 Selection of Respondents

The beneficiaries who were involved in Social Forestry programmes in between the period from 1983/84 to 1996/97 were considered as the respondents of this study. The rationale of preferring the period was to sort out the beneficiaries who had the probability to accrue some benefits from SF. Lists of Local Community Organisations (LCO) were collected from Rajshahi Social Forest Division and the two national NGOs-PROSHIKA and CARITAS. Two hundred twenty LCOs were identified as the data universe of the study (Table 3.1). From 220 Local Community Organisations, 20% (44 nos.) of the LCOs was selected using the proportionate stratified random sampling method. The sample size of LCOs for Godagari, Niamotpur and Nachol were 20, 12, and 12 respectively. Finally, from 44 LCOs, 120 (60 respondents each from the FD & NGOs) respondents were selected randomly (Table 3.2).

Table 3.1: Number of Local Community Organisations in the Study Area Involved in Social Forestry from 1983/84 to 1996/97

Organization	Project Name	Duration	Godagari	Nachol	Niamotpur	Total
Forest Dept.	CFDP	83/84- 86/87	34	0	31	65
Forest Dept.	Revenue	90-91	0	3	0	3
Forest Dept.	TPND	93/94-95/96	35	12	6	53
Forest Dept.	FEP	94/95-96/97	8	6	12	26
LCOs of NGO sponsored SF projects						
PROSHIKA	WFP project	94/95-96/97	22	31	0	53
CARITAS	WFP project	95/96-96/97	3	8	9	20
		Total	102	60	58	220

Source: Abu Naser Khan, DFO, Rajshahi Social Forest Division (Personal Communication, January 2004); Prodip Kumar Chakrabarti, Area Co-coordinator, PROSHIKA, Godagari (Personal Communication, January 2004); Shisir Biswas, Plantation In-Charge, CARITAS, Rajshahi (Personal Communication, January 2004).

Table 3.2: Distribution of Respondents by Organisation and Upazila

Upazila		No. of Respondent	Percent	Upazila percent
Godagari	Forest Department	28	57	41
	NGOs	21	43	
Nachol	Forest Department	13	37	29
	NGOs	22	63	
Niamotpur	Forest Department	19	53	30
	NGOs	17	47	
Total	Forest Department	60	50	100
	NGOs	60	50	

3.2.1.3 Environmental Perception of Respondents

A pre-present approach was followed for assessing the perception about the impact of SF on different environmental components. The components were: soil fertility, soil erosion, temperature, rainfall, plant diversity, number of birds and diversity of birds. The respondents were asked to compare the present situation with the pre-SF situation of local environment and rank the SF impacts qualitatively as 'Positive impact', 'No impact', and 'Negative impact'.

Chapter Four

Study of Environmental Impacts

CHAPTER IV

STUDY OF ENVIRONMENTAL IMPACTS

4.1 Introduction

This Chapter examines the environmental impacts of SF, which are intrinsically related to one of the core objectives of SF, i.e. restoration of ecosystem balance. This chapter also analyses the perception of beneficiaries about the impact of SF on the environmental components. Ecological restoration is a subject that receives considerable attention in many parts of the world. Several alarming environmental problems such as: climate change, loss of biodiversity, pollution, desertification, soil water erosion, declining soil fertility, loss of soil organic matter, over flood, drought, increased sediment transport and dwindling forest cover as well as forest resources veer the global interest and attention towards restoration. (Rocheleau, Weber and Field, 1988; Cairns, 2002). The rationale for restoration of ecosystem balance in Bangladesh goes beyond the aforementioned issues, which essentially includes the sustainable rural development. At present, the country is increasingly facing depletion of forest resources and biodiversity alarmingly due to increased intensive land use and deteriorating socio-economic conditions in rural areas. In order to redress the problems of fuelwood scarcity, biodiversity and land degradation extensive plantation/afforestation projects have been implemented under different SF projects since early 1980s in Bangladesh.

The study area is country's most environmentally vulnerable and one of the economically downtrodden areas. In the last two decades, the FD and NGOs carried out extensive afforestation activities in the study area for ecological restoration. However,

these afforestation activities were largely confined to monoculture plantations. Exotic fast growing species were preferred in these plantations. *Dalbergia sissoo* Roxb. was the most preferred species and the subsequently preferred species were *Acacia auriculiformis* A cunn. ex Benth., *Swietenia mahagoni* (L.) Jacq., *Eucalyptus sp.* and so forth. Sustainability of exotic species plantation in terms of environmental, economic and social dimensions is a controversial issue. Some researchers are arguing that these species exhaust soil water and nutrient resources, and prevent understorey vegetation growth, which causes losses of biodiversity, accelerates soil erosion and depletes soil fertility (Poore and Fries, 1985; Abbasi and Vinithan, 1997). Some researchers have expressed a different opinion that, fast growing species plantations can act as catalyst of biodiversity rehabilitation on degraded tropical lands and help regeneration of undergrowth, thus increase the biodiversity and fertility of degraded lands (Parrotta, 1995; Geldenhuys, 1997; Harrington and Ewel, 1997). Both the views are not empirically tested in case of plantation forestry practices in Bangladesh. This chapter examines empirically the impacts of plantations on the understorey vegetation and some of the soil fertility parameters of three sites of the High Barind Tract under this study. Positive perception of community people is essential for any development intervention to be successful in natural resource management. This chapter also attempts to measure the perception of beneficiaries regarding the impact of SF on environmental components.

4.2 Results

4.2.1 Effect of Plantation on Soil Properties

Soil provides essential chemical elements for plant growth. Soil productivity depends on soil fertility. The fertility of a soil depends on soil texture, content of organic matter (humus), content of several chemical elements – such as N, P, K and many others; cation exchange capacity, exchangeable bases, pH, clay minerals, content of mineral resources in the undecomposed rocks in and below the soil and other factors (Steven, 1987). In this study, analyses of soil samples were done to find out the effects or changes of soil properties due to afforestation activities carried out under SF projects. The results of the chemical analyses of Plantation soil (PS) and reference soil i.e. Non-Plantation soil (NPS) are presented in Table 4.1. It shows that soils of both the categories of land use were acidic in nature. In site A and site C, the NPSs were more acidic (pH 6.58 and pH 6.38) than their respective PSs (pH 6.72 and pH 6.51). In site B, the PS was more acidic (pH 4.83) than its respective NPS (pH 5.23). Under this investigation, it was observed that the content of some soil fertility parameters such as organic matter, K, total nitrogen, B, Mn, and Zn were higher in the PSs than their respective NPSs. The content of Ca and P were also higher in the PSs than their respective NPSs except site B and the content of Mg was higher in the PSs than their respective NPSs except site A. On the other hand, the content of some soil chemical parameters- Cu and Fe were less in the PSs than their respective NPSs. There were significant differences between some chemical constituents of the PSs and the NPSs. The soil attributes of PSs and NPSs were compared using t-Test. The result showed that there were significant differences ($P < 0.05$) between these soils in case of total nitrogen, K and Cu (Appendix D).

Table 4.1: Physico-chemical Characteristics of Plantation soils and Non-Plantation soils

Site		Year	pH	O.M	K	Ca	Mg	TN	P	S	B	Cu	Fe	Mn	Zn
				%	meq/100gm soil			%	$\mu\text{gm/ gm soil}$						
Site A	NPS	Y1	6.10	1.45	0.22	5.20	3.20	0.08	3.93	7.02	0.31	2.70	140.00	40.00	0.96
		Y2	7.05	1.16	0.24	4.40	2.20	0.06	3.57	15.60	0.30	2.00	40.00	17.00	1.20
		Avg.	6.58	1.31	0.23	4.80	2.70	0.07	3.75	11.31	0.31	2.35	90.00	28.50	1.08
	PS	Y1	6.50	2.30	0.32	5.50	1.90	0.12	4.42	6.21	0.37	1.24	51.00	40.00	1.26
		Y2	6.94	1.20	0.50	4.50	2.00	0.10	6.24	16.69	0.34	1.20	25.00	30.00	1.30
		Avg.	6.72	1.75	0.41	5.00	1.95	0.11	5.33	11.45	0.36	1.22	38.00	35.00	1.28
Site B	NPS	Y1	5.00	2.02	0.12	4.80	1.20	0.11	2.12	10.48	0.29	4.46	261.00	16.00	0.72
		Y2	5.45	1.84	0.14	4.40	1.10	0.09	11.60	15.87	0.23	2.80	40.00	17.00	0.70
		Avg.	5.23	1.93	0.13	4.60	1.15	0.10	6.86	13.18	0.26	3.63	150.50	16.50	0.71
	PS	Y1	4.75	2.38	0.35	3.30	2.10	0.12	3.25	4.35	0.30	2.00	201.00	70.00	1.20
		Y2	4.90	1.84	0.37	1.90	1.30	0.09	4.01	20.52	0.19	1.80	100.00	64.00	0.40
		Avg.	4.83	2.11	0.36	2.60	1.70	0.11	3.63	12.44	0.25	1.90	150.50	67.00	0.80
Site C	NPS	Y1	6.25	1.50	0.29	4.40	1.70	0.09	2.13	7.71	0.18	2.42	100.00	20.40	0.72
		Y2	6.50	1.50	0.19	4.80	0.90	0.05	4.46	14.78	0.19	2.00	56.00	8.00	0.66
		Avg.	6.38	1.50	0.24	4.60	1.30	0.07	3.30	11.25	0.19	2.21	78.00	14.20	0.69
	PS	Y1	6.50	2.90	0.20	7.80	2.30	0.14	2.18	5.47	0.43	1.22	85.00	40.00	1.70
		Y2	6.52	3.13	0.40	4.70	1.60	0.15	5.35	6.58	0.57	0.90	120.00	10.00	1.40
		Avg.	6.51	3.02	0.30	6.25	1.95	0.15	3.77	6.03	0.50	1.06	102.50	25.00	1.55

Y1=Year 1, Y2=Year 2,

4.2.2 Comparison of Effects Caused by Exotic and Native-mixed Plantations on Soil Properties

Comparison among the attributes of the Plantation Soils (PSs) and their percentage of changes in relation to the attributes of Non Plantation Soils (NPSs) are given in Table 4.2. The results showed that the soil of native-mixed plantation (*Terminalia arjuna* (Roxb.) Wt. & Arn + *Mangifera indica* L.) in site C contained the highest percentage of organic matter (3.02%) and total nitrogen (0.15%) and the highest amounts of Ca (6.25 meq/100gm), B (0.50 $\mu\text{gm/gm}$) and Zn (1.55 $\mu\text{gm/gm}$). The soil of *Acacia auriculiformis* A. cunn. ex Benth. plantation in site B contained the highest amounts of S (12.44 μgm), Cu (1.90 $\mu\text{gm/gm}$), Fe (150.50 $\mu\text{gm/gm}$) and Mn (67 μ

gm/gm) while the soil pH value of this site was the lowest (4.83) among the three sites. In site A, the soil of *Dalbergia sissoo* Roxb. plantation contained the highest amount of K (0.41meq/100gm) and P (5.53 μ gm/gm).

In the three sites considering the NPSs' attributes as reference, the percentage of changes of PSs' attributes were calculated. The soil of native-mixed plantation in site C showed the highest positive changes in organic matter (101%), total nitrogen (107.14%), Ca (35.87%), Mg (50.00%), B (170.27%), Fe (31.41%) and Zn (124.64%). In site B, the soil of *Acacia auriculiformis* A cunn. ex Benth. plantation showed the highest positive changes in K (176.92%) and Mn (306.06%). In site A, the soil of *Dalbergia sissoo* Roxb. plantation showed the highest positive change in P (42.13%). On the other hand, the soil of *Acacia auriculiformis* A cunn. ex Benth. plantation in site B, showed acidic trend (pH value change -7.66%) as well as showed negative changes in some soil attributes namely Ca (-43.48%), P (-47.08%), S (-5.62%), B (-5.77%), and Cu (-47.66%). In site A, the soil of *Dalbergia sissoo* Roxb. plantation showed negative changes in Mg (-27.78%), Cu (-48.09) and Fe (-57.78%) and in site C, the soil of native-mixed plantation showed negative changes in S (-46.42%) and Cu (-52.04%).

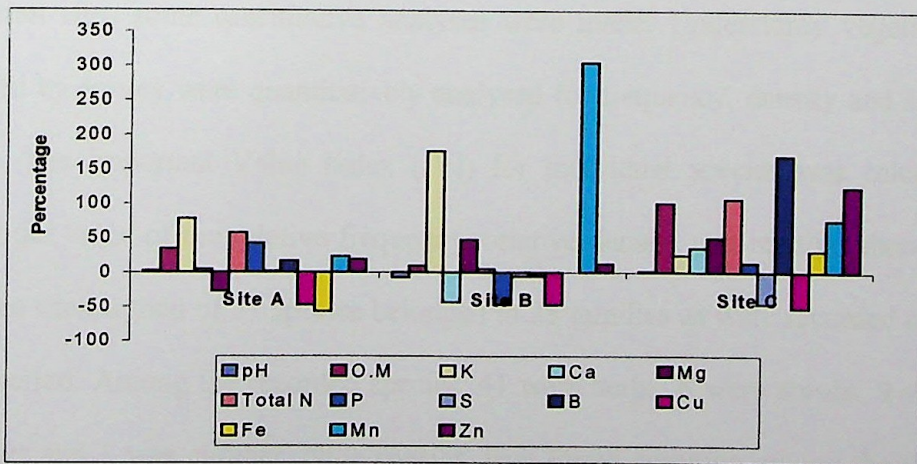


Figure 4.1 Changes of soil parameters (%) of three plantation sites in relation to their respective reference sites

Table 4.2: Changes of Soil Parameters (%) of three Plantation Sites in Relation to their Respective Reference Sites

(Data means of 2 replications)

		PS			NPS			% of Change		
	Unit	Site A	Site B	Site C	Site A	Site B	Site C	Site A	Site B	Site C
pH		6.72	4.83	6.51	6.58	5.23	6.38	2.21	-7.66	2.12
O.M	%	1.75	2.11	3.02	1.31	1.93	1.50	34.10	9.33	101.00
K	meq/100g in soil	0.41	0.36	0.30	0.23	0.13	0.24	78.26	176.92	25.00
Ca		5.00	2.60	6.25	4.80	4.60	4.60	4.17	-43.48	35.87
Mg		1.95	1.70	1.95	2.70	1.15	1.30	-27.78	47.83	50.00
Total N	%	0.11	0.11	0.15	0.07	0.10	0.07	57.14	5.00	107.14
P	μ gm/gm soil	5.33	3.63	3.77	3.75	6.86	3.30	42.13	-47.08	14.26
S		11.45	12.44	6.03	11.31	13.18	11.25	1.24	-5.62	-46.42
B		0.36	0.25	0.50	0.31	0.26	0.19	16.39	-5.77	170.27
Cu		1.22	1.90	1.06	2.35	3.63	2.21	-48.09	-47.66	-52.04
Fe		38.00	150.50	102.50	90.00	150.50	78.00	-57.78	0.00	31.41
Mn		35.00	67.00	25.00	28.50	36.50	14.20	22.81	306.06	76.06
Zn		1.28	0.80	1.55	1.08	0.71	0.69	18.52	12.68	124.64

PS=Plantation Soil, NPS=Non-Plantation Soil

4.2.3 Floristic Composition and Distribution of Understorey Flora

4.2.3.1 Analytic Characters

In order to get the phytosociological picture of understorey flora of the three plantation sites some quantitative analyses were made. Understorey vegetation data obtained by survey were quantitatively analysed for frequency, density and abundance values. The Important Value Index (IVI) for individual species was calculated by adding the value of the relative frequency, relative density and relative abundance. In the three sites, a total of 57 species belonged to 25 families as were recorded during the study period. Among the recorded species, 41 were herbs, 6 were shrubs, 9 were tree-seedlings and 1 was climber. Nine species were found common among the three sites (Appendix E). Site A contained 26 species belonging to 12 families while site B had 30 species under 16 families and site C contained 42 species under 21 families (Table 4.3).

Table 4.3: Distribution of Understorey Plant Species in Three Sites During Study Period

Site	Plant Type				Total no. of Species	No. of families
	Herb	Shrub	Tree seedling	Climber		
Site A	21	1	4	0	26	12
Site B	27	0	2	1	30	16
Site C	31	5	6	0	42	21

I. Site A

In this site, 26 species were recorded during the study period. They were four tree seedlings, one shrub and twenty-one herbs species. In general, grasses and other ground layer species were the most prevalent and widely distributed in the site.

Rainy Season

Floristic Composition and Analytic Characters: Floristic composition and analytic characters of the understorey plant species in site A during the rainy season are shown in Table 4.7a. In this site, a total of 18 species were recorded during the rainy season. Of them 15 were herbs and 3 were tree-seedlings. Among the species found in the site *Evolvulus nummularius* L., *Brachiaria* sp, *Achyranthes aspera* L., *Sida cordifolia* L., *Oplismenus compositus* (L.) P. Beauv., *Cynodon dactylon* Pers., were noteworthy. In the tree-seedling group, *Azadirachta indica* A. Juss. showed the highest frequency value (15%) and the highest density value (0.4) while *Dalbergia sissoo* Roxb. showed the highest abundance value (0.6). In the herb layer, *Brachiaria* sp showed the maximum frequency value (100%). Frequency values of *Croton bonplandianum* Bail, *Evolvulus nummularius* L. and *Achyranthes aspera* L. were in the 81-100% frequency class . These species were constantly present in the site.

Sida cordifolia L. and *Oplismenus compositus* (L.) P. Beauv. were mostly present and their frequency values were in the frequency class of 61-80%. *Paspalidium flavidum* (Retz.) A. Camus, *Eragrostis unioides* (Retz.) Nees. and *Cynodon dactylon* Pers. were often present in the site and their frequency values were in the frequency class of 41-60% . *Evolvulus nummularius* L. showed the highest density value (42.3) and the highest abundance value (44.4) followed by *Brachiaria sp* (34.7, 34.7). *Achyranthes aspera* L., *Sida cordifolia* L., and *Oplismenus compositus* (L.) P. Beauv. showed relatively high density values of 14.6, 13.8 and 10.7 respectively.

Importance Value Indices (IVI): IVI of different understorey plant species in site A during the rainy season are shown in Table 4.7b. In this season, *Evolvulus nummularius* L. showed the highest IVI (64.7) followed by *Brachiaria sp* (54.8), *Achyranthes aspera* L. (30.0), *Sida cordifolia* L. (29.0) and *Oplismenus compositus* (L.) P. Beauv. (24.3). The relative abundance values of *Evolvulus nummularius* L. and *Brachiaria sp* were 23.2 and 18.1 respectively which indicate that these species made up more than 40% of the understorey flora in site A . Considering the IVI of the plant species in site A, it can be mentioned that *Evolvulus nummularius* L. and *Brachiaria sp*, were the dominant species during the rainy season.

Winter Season

Floristic Composition and Analytic Characters: Floristic composition and analytic characters of the understorey plant species in site A during the winter season are shown in Table 4.8a. A total number of 9 species were recorded. Of them 2 were tree-seedlings (*Azadirachta indica* A. Juss. and *Dalbergia sissoo* Roxb.) and 7 were herbs. *Evolvulus nummularius* L., *Brachiaria sp*, *Achyranthes aspera* L., *Sida cordifolia* L. and *Croton bonplandianum* Bail. were the prominent species in the site during the

winter season. *Evolvulus nummularius* L. showed the highest 100% frequency value. Frequency values of *Brachiaria sp* and *Achyranthes aspera* L. were in the 81-100% frequency class. These species were constantly present in the site. *Sida cordifolia* L. showed the frequency value of 75%. *Croton bonplandianum* Bail. also showed a notable frequency value of 60%. *Brachiaria sp* showed the highest density value (28.7) and the highest abundance value (30.6) followed by *Evolvulus nummularius* L. (22.9, 22.9). Rest of the species showed low density and abundance values (below 10) except the abundance value of *Sida cordifolia* L. (14.5).

Importance Value Indices (IVI): IVI of different understorey plant species in site A during the winter season are shown in Table 4.8b. Among the species, *Brachiaria sp* had the highest IVI of 80.5. *Evolvulus nummularius* L. showed the second highest IVI of 78.2. The species those possessed notable IVI were *Sida cordifolia* L. (46.3), *Achyranthes aspera* L. (35.2) and *Cynodon dactylon* Pers. (19.9). The relative abundance values of *Brachiaria sp* and *Evolvulus nummularius* L. were 28.6 and 24.9 respectively, and thus it indicated that these species made up more than 50% of the understorey flora in site A during the winter season. Therefore, the plant community of site A during this season was co-dominated by *Brachiaria sp* and *Evolvulus nummularius* L.

Summer Season

Floristic Composition and Analytic Characters: Floristic composition and analytic characters of the understorey plant species in site A during the summer season are shown in Table 4.9a. During this season, a total of 16 species were recorded. Of them 3 species were tree seedlings. They were *Azadirachta indica* A. Juss., *Dalbergia sissoo* Roxb. and *Zizyphus mauritiana* Lamk. Remaining thirteen species were herbs.

Among the 13 herbs species *Evolvulus nummularius* L., *Brachiaria sp*, *Achyranthes aspera* L., *Imperata cylindrica* (L.) P. Beauv., and *Croton bonplandianum* Bail. were noteworthy. During this season, *Evolvulus nummularius* L., *Brachiaria sp* and *Achyranthes aspera* L. were constantly present in the site and their frequency values were in the 81-100% frequency class. *Croton bonplandianum* Bail. and *Digitaria sanguinalis* (L.) Scop. were mostly present and their frequency values were in the 61-80% frequency class. *Brachiaria sp*. showed the highest density value (28.1) and the highest abundance value (28.9) followed by *Evolvulus nummularius* L. (22.4, 22.4). Rest of the species showed relatively low density and abundance values (below 10) except the density and abundance values of *Digitaria sanguinalis* (L.) Scop. (12, 13.9) and *Achyranthes aspera* L. (11.6, 13.4).

Importance Value Indices (IVI): IVI of different understorey plant species in site A during the summer season are shown in Table 4.9b. Similar to the frequency, density and abundance values, the two major species, *Brachiaria sp* and *Evolvulus nummularius* L. showed the IVI of 73.1 and 66.9 respectively. Three other competing species were *Achyranthes aspera* L., *Digitaria sanguinalis* (L.) Scop. and *Croton bonplandianum* Bail. with IVI of 42.3, 41.5 and 21.7 respectively. On the other hand, *Eleusine indica* (L.) Gaertn., *Flacourtia indica*(Brum. f.) Merr. and a tree seedling (*Zizyphus mauritiana* Lamk.) showed IVI ranging from 1.1-1.3. Therefore, they were sparsely distributed. The relative abundance values of *Brachiaria sp* and *Evolvulus nummularius* L. were 27.9 and 22.5 respectively and they made up 50% of the understorey flora in the site during the summer season. Considering the IVI of the plant species in site A during this season, *Evolvulus nummularius* L. and *Brachiaria sp* were co-dominant species.

II. Site B

In site B, a total of 30 species were found during the study period. Among them, 2 were tree seedlings, 1 was climber and rest of the species were from the herb group. Grasses were widely distributed and dominant species in the site during the study period.

Rainy Season

Floristic Composition and Analytic Characters: Floristic composition and analytic characters of the understorey plant species in site B during the rainy season are shown in Table 4.10a. A total of 20 species were found in this season. Except the only tree seedling, nineteen species were herbs. *Acacia auriculiformis* A. Cunn. ex Benth. was the only tree seedling, which showed frequency value of 50%, density value of 0.9 and abundance value of 2. Among the herbs, *Oplismenus compositus* (L.) P. Beauv., *Brachiaria sp.*, *Hemigraphis hirta* T. Anders. and *Cynodon dactylon* Pers. were noteworthy. *Brachiaria sp.* and *Oplismenus compositus* (L.) P. Beauv. showed the highest 100% frequency value. The frequency values of *Hemigraphis hirta* T. Anders., *Croton bonplandianum* Bail. and *Cynodon dactylon* Pers. were in the frequency class of 81-100%. These species were constantly present in the site. *Alysicarpus vaginalis* DC., *Desmodium triflorum* (L.) DC., *Eleusine indica* (L.) Gaertn. were often present and they showed the frequency values ranging from 41-60%. The highest density value (41.3) and the highest abundance value (41.3) were shown by *Oplismenus compositus* (L.) P. Beauv. followed by *Brachiaria sp.* (24.4, 24.4). The herb species that showed notable density and abundance values were *Hemigraphis hirta* T. Anders. (20, 21.1) and *Cynodon dactylon* Pers. (11.8, 14.1).

Importance Value Indices (IVI): IVI of different understorey plant species in site B during the rainy season are shown in Table 4.10b. Among the species, *Oplismenus compositus* (L.) P. Beauv. showed the highest IVI of 69.3 followed by *Brachiaria sp* (45.6). On the other hand, *Cassia sophera* L. showed the lowest IVI of 1.1. The herb species with relatively high IVI were *Hemigraphis hirta* T. Anders. (39.7), *Cynodon dactylon* Pers. (27.6), *Alysicarpus vaginalis* DC. (16), *Croton bonplandianum* Bail. (15.3) and *Desmodium triflorum* (L.) DC. (12.5). Considering the IVI of the understorey plant species in site B, *Oplismenus compositus* (L.) P. Beauv., and *Brachiaria sp* were the two co-dominant species.

Winter Season

Floristic Composition and Analytic Characters: Floristic composition and analytic characters of the understorey plant species in site B during the winter season are shown in Table 4.11a. The total number of species as recorded during the winter season in site B was 17. Of them, *Acacia auriculiformis* A cunn. ex Benth. was the only tree seedling and rest of the species were herbs. The only tree seedling *Acacia auriculiformis* A cunn. ex Benth. showed 45% of frequency, 1.2 of density and 1.3 of abundance values. In the herb group, *Cynodon dactylon* Pers. showed the highest frequency value of 90%. On the other hand, frequency values of *Oxalis corniculata* L. and *Hemigraphis hirta* T. Anders. were in the frequency class of 21-40%, and they were seldom present in the site. Frequency values of *Evolvulus nummularius* L., *Alysicarpus vaginalis* DC. and *Cyperus rotundus* L. were in the frequency class of 41-60%. These species were often present in the site. *Evolvulus nummularius* L. showed the frequency value of 65% and the species was mostly present in the site. During this season *Cynodon dactylon* Pers. showed the highest density value (12.7) and the second

highest abundance value (13.7). On the other hand, *Centella asiatica* (L) Urban. showed the lowest density (0.2) value. *Evolvulus nummularius* L. showed the highest abundance value (14.2) and the second highest density value (7.9).

Importance Value Indices (IVI): IVI of different understorey plant species in site B during the winter season are shown in Table 4.11b. Among the plant species recorded in the site B during this season, *Cynodon dactylon* Pers. showed the highest IVI of 84. An IVI of 62.5 was shown by *Evolvulus nummularius* L. The two notable species with relatively high IVI were *Cyperus rotundus* L. (21.9) and *Alysicarpus vaginalis* DC. (21.7). The lowest IVI was shown by *Centella asiatica* (L) Urban. (2.9). Rest of the species present in the site showed relatively low IVI ranging from 2.9 to 15. The relative abundance values of *Cynodon dactylon* Pers. and *Evolvulus nummularius* L. were 26.9 and 23 respectively and they made up about 50% of the understorey plant community in site B. Considering IVI of the plant species in this site, the dominant species during the winter season were *Cynodon dactylon* Pers. and *Evolvulus nummularius* L. These two species belonged to the ground layer.

Summer Season

Floristic Composition and Analytic Characters: Floristic composition and analytic characters of the understorey plant species in site B during the summer season are shown in Table 4.12a. In this season, a total number of 19 species were met with in site B. Two tree seedlings (*Acacia auriculiformis* A. cunn. ex Benth., *Azadirachta indica* A. Juss.) and a climber (*Vitis trifolia* (L.) Don) were recorded here and the remaining 17 species were herbs. Among the species as recorded in the site, *Isachne miliacea* Roth., *Evolvulus nummularius* L., *Cyperus rotundus* L., *Eleusine indica* (L.) Gaertn. and *Imperata cylindrica* (L.) P. Beauv. were notable. The highest frequency value of 90%

was shown by *Isachne miliacea* Roth. and *Eleusine indica* (L.) Gaertn. They were widely distributed in the site. *Evolvulus nummularius* L. and *Cynodon dactylon* Pers. were mostly present and showed frequency values ranging from 61-80%. Frequency values of *Cyperus rotundus* L., *Croton bonplandianum* Bail. and *Sporobolus diander* (Retz.) P. Beauv were in the frequency class of 41-60%. These species were often present in the site. *Isachne miliacea* Roth. exhibited the highest density value (110.5) and the highest abundance value (113). The second highest density value (19.4) and the second highest abundance value (22.3) were shown by *Evolvulus nummularius* L. The species with relatively high density and abundance values were *Eleusine indica* (L.) Gaertn. (18.8, 18.9), *Cyperus rotundus* L. (18.7, 24.6) and *Cynodon dactylon* Pers. (10.9, 16.4). Rest of the species showed comparatively low (below 10.0) density and abundance values.

Importance Value Indices (IVI): IVI of the understorey plant species as found during the summer season in site B are shown in Table 4.12b. Among the herbaceous plant species, *Isachne miliacea* Roth. showed the highest IVI of 103. The relative abundance of *Isachne miliacea* Roth. was 40.9, which indicated that the species made up the major portion of the understorey flora during the summer season in site B. On the contrary, *Vitis trifolia* (L.) Don and *Clerodendrum viscosum* Vent. showed the lowest IVI of 0.7. In the tree seedling group, *Acacia auriculiformis* A. Cunn. ex Benth. and *Azadirachta indica* A. Juss. showed the IVI of 7.2 and .09 respectively. The species which showed relatively high IVI were *Evolvulus nummularius* L. (39.6), *Eleusine indica* (L.) Gaertn. (41.2), *Cyperus rotundus* L. (39.4) and *Cynodon dactylon* Pers. (26.4). Therefore, the co-dominant species during the summer season in site B were *Isachne miliacea* Roth., *Eleusine indica* (L.) Gaertn., *Evolvulus nummularius* L. and *Cyperus rotundus* L..

III. Site C

In site C, a total number of 42 herbs, shrubs and tree seedlings were recorded. Out of 42 species, 6 were tree seedlings, 5 were shrubs and rest of the species were herbs.

Rainy Season

Floristic Composition and Analytic Characters: Floristic composition and analytic characters of the understorey plant species in site C during this season are shown in Table 4.13a. The total number of species as recorded during the rainy season in site C was 28. Of them, 3 were shrubs, 6 were tree seedlings and 20 were herbs. Among the herb species, *Evolvulus nummularius* L. and *Eleusine indica* (L.) Gaertn. showed the maximum 100% frequency value. *Desmodium triflorum* (L.) DC. exhibited 90% frequency value. Frequency values ranging from 61-80% were shown by *Echinochloa colonum* (L.) Link., *Oplismenus compositus* (L.) P. Beauv. and *Ichnanthus vicinus* (Bail) Merr., and they were mostly present in the site. On the contrary, *Cassia sophera* L., *Lippia nodiflora* (L.) Rich. and *Amaranthus viridis* L. showed the frequency values in the frequency class of 0-20% and these species were rarely present in the site. In the shrub group, *Clerodendrum viscosum* Vent. showed the highest frequency value of 45%. *Cassia sophera* L. and *Glycosmis pentaphylla* (Retz.) A. DC. were rarely present and showed low frequency values. In the tree seedlings group, *Azadirachta indica* A. Juss. and *Terminalia arjuna* (Roxb.) Wt. & Arn showed the frequency values of 30% and 25% respectively. Rest of the tree seedlings showed frequency values ranging from 0-20%. Among all of the species present in site C during the rainy season, *Eleusine indica* (L.) Gaertn. showed the highest density value (30) and the highest abundance value (30) followed by *Evolvulus nummularius* L. (25.2, 25.2) and *Desmodium triflorum* (L.) DC. (13.5, 15.1).

Importance Value Indices (IVI): IVI of the understorey plant species found during the rainy season in site C are shown in Table 4.13b. In this site, the IVI of the two major herbaceous species *Eleusine indica* (L.) Gaertn. and *Evolvulus nummularius* L. were 45.1 and 40 respectively. Besides these species, *Desmodium triflorum* (L.) DC. and *Oplismenus compositus* (L.) P. Beauv. showed notable IVI of 26 and 24.3 respectively. Rest of the herbaceous species showed the IVI ranging from 2.8 to 16.1. The shrub species present in the site during the rainy season showed relatively low IVI ranging from 1.1 to 6.0. Among the tree seedlings, *Azadirachta indica* A. Juss. showed the highest IVI of 4.4 while *Syzygium cumini* Skeel. and *Zizyphus mauritiana* Lamk. showed the IVI of 1.3 and 1.2 respectively. Considering the IVI of the species present in the site C during the rainy season, *Eleusine indica* (L.) Gaertn. and *Evolvulus nummularius* L. were the two co-dominant species.

Winter Season

Floristic Composition and Analytic Characters: In this season, a total number of 19 understorey plant species were recorded. Of them 2 were shrubs, 5 were tree seedlings and 12 were herbs (Table 4.14a). Among the herb species *Eleusine indica* (L.) Gaertn. and *Evolvulus nummularius* L. showed the maximum frequency value of 100%. *Eleusine indica* (L.) Gaertn. showed the highest density value (30.2) and the highest abundance value (30.2) followed by *Evolvulus nummularius* L. (13.8, 13.8). The species showing notable frequency values were *Achyranthes aspera* L. and *Nelsonia campestris* R. Br. Their frequency values were in the 41-60% frequency class and these species were often present in the site during the winter season. *Cyperus rotundus* L., *Desmodium triflorum* (L.) DC. and *Solanum nigrum* L. showed relatively low frequency values. Their frequency values were in the 0-20% frequency class. Five tree

seedlings were recorded in this season. Of them *Azadirachta indica* A. Juss. and *Phoenix sylvestris* (L.) Roxb. showed the highest frequency value of 20%, and *Zizyphus mauritiana* Lamk. showed the lowest frequency value of 5%.

Importance Value Indices (IVI): IVI of different understorey plant species found during the winter season in site C are shown in Table 4.14b. In this site, *Eleusine indica* (L.) Gaertn. exhibited the highest IVI of 87.8 followed by *Evolvulus nummularius* L. (55.4). The species showing notable IVI were *Nelsonia campestris* R. Br. (31.6), *Achyranthes aspera* L. (23.2) and *Sporobolus diander* (Retz.) P. Beauv. (18.7). Among the tree seedlings *Azadirachta indica* A. Juss. showed the highest IVI of 5.6. Considering the IVI of the plant species in site C, it could be mentioned that *Eleusine indica* (L.) Gaertn. and *Evolvulus nummularius* L. were the two dominant species during the winter season.

Summer Season

Floristic Composition and Analytic Characters: In site C, a total of 23 understorey plant species were recorded during the summer season. Of them 15 were herbs, 3 were tree seedlings and 5 were shrubs (Table 4.15a). Among the species recorded in the site, the frequency values of *Evolvulus nummularius* L. and *Eleusine indica* (L.) Gaertn. were in the highest frequency class of 81-100%. Frequency values ranging from 41-60% were shown by *Cyperus rotundus* L., *Dichanthium annulatum* (Forsk.) Stapf. These species were often present in the site. Frequency values ranging from 21-40% were shown by *Brachiaria* sp, *Eragrostis tenella* (L.) P. Baeuv., *Nelsonia campestris* R. Br. and *Paspalidium flavidum* (Retz.) A. Camus and these species were seldom present. Rest of the herbaceous species showed frequency values up to 20%. Among the tree seedlings, *Azadirachta indica* A. Juss. showed the highest frequency

value of 20%. *Evolvulus nummularius* L. showed the highest density value (18.2) and the highest abundance value (18.2) followed by *Eleusine indica* (L.) Gaertn. (16.5, 17.1). Rest of the species showed relatively low density and abundance values.

Importance Value Indices (IVI): IVI of different understorey plant species recorded during the summer season in site C are shown in Table 4.15b. In this site, the IVI of two major species *Eleusine indica* (L.) Gaertn. and *Evolvulus nummularius* L. were 63.7 and 63.2 respectively. On the other hand, *Flacourtia indica* (Brum. f.) Merr., *Cassia sophera* L., *Calotropis procera* Br. and *Lantana camara* L. Var. showed relatively low IVI ranging from 0.6 to 2.8. The three notable species in the site- *Dichanthium annulatum* (Forsk.) Stapf., *Brachiaria sp* and *Oplismenus compositus* (L.) P. Beauv. showed the IVI of 24.6, 15.9 and 14.1 respectively. Considering the IVI of the understorey plant species present in site C during the summer season, *Eleusine indica* (L.) Gaertn. and *Evolvulus nummularius* L. were the two dominant species.

4.2.3.2 Synthetic Character

The Jaccard's Community Co-efficient values among the three understorey plant communities demonstrated that the two exotic plantation sites (site A and site B) under this study support different types of plant communities, as the lowest similarity was observed between the understorey plant communities of these sites. They had a Jaccard's community coefficient value of 27.27% and 12 common species were recorded from these two communities. The maximum similarity of 41.67% was observed between the understorey plant communities of site A and site C. The number of common species between these plant communities was 20. There was a 35.85% similarity between the understorey plant communities of site B and site C. A total of 19 common species was recorded from these plant communities (Table 4.4).

Table 4.4: Jaccard's Community Co-efficient (%) between Pairs of Understorey Plant Communities of Three Plantation Sites

Sites	Site B	Site C
Site A	27.27 (12)	41.67 (20)
Site B		35.85 (19)

Note: Values in the parenthesis are the common species between the sites

4.2.4 Phytodiversity

The summary results of phytodiversity of the sites are shown in Table 4.5 and detail calculations are shown in Appendices (F-H). During the study period, in site C, a total of 42 species belonging to 21 families were recorded. Among the species recorded in site C, 6 were tree seedlings, 5 were shrubs and 31 were herbs. In site B, a total of 30 species belonging to 16 families were recorded. Of them, 2 were tree seedlings, 1 was climber and 27 were herbs. Site A showed the lowest understorey species diversity. A total of 26 species belonging to 12 families were recorded from this site. Of them, 4 were tree seedlings, 1 was shrub and 21 were herbs. Among the three sites, the Shannon's diversity index was maximum in site C ($H=2.65$) and minimum in site A ($H=2.02$). Site B showed the Shannon's diversity index value of 2.31. The dominance indices of understorey plant community of the three plantation sites were however observed to be the highest in site A ($D=0.19$) and the lowest in site C (0.13). The index of dominance in site B was 0.15. In case of community evenness, site C were found to be more even (0.71) than the understorey plant communities of site A (0.63) and site B (0.68). The results in general indicated the trend of inverse relationship between diversity and dominance and between diversity and evenness.

Table 4.5: Phytodiversity of Understorey Plant Communities of Three Sites during Study Period

Phytodiversity		Site A	Site B	Site C
No. of Species	Herb	21	27	31
	Shrub	1	0	5
	Climber	0	1	0
	Tree seedling	4	2	6
	Total	26	30	42
No. of families		12	16	21
Shannon's index (H)		2.02	2.31	2.65
Index of Dominance (D)		0.19	0.15	0.13
Evenness (E)		0.63	0.68	0.71

4.2.5 Statistical Analysis of Edaphic and Phytosocial Variables

4.2.5.1 Analysis of Variance

The number of species and number of individual plants indicate the diversity and productivity of any site. Two-way analyses of variance (ANOVAs) were carried out to evaluate the effect of site and season on number of species and number of individual plants. The results of ANOVAs are shown in Appendix I. The results indicated significant interactions between number of species $\times$ sites ($n=3$, $F=16.08$, $P<0.05$) and number of species $\times$ seasons ($n=3$, $F=9.91$, $P<0.05$). There were no significant interactions between number of individual plants $\times$ sites and number of individual plants $\times$ seasons.

4.2.5.2 Correlation Structure

A Correlation analysis was performed among all of the edaphic and phytosocial variables as measured in the three sites. Some pairs of variables showed significant correlation between them (Appendix K). The pairs of variables with significant positive correlations were: Organic matter and Number of species ($P<0.05$); Ca and Zn ($P<0.05$); Cu and Mn ($P<0.05$); Cu and number of individual plants ($P<0.05$); Mn and number of individual plant ($P<0.05$). The pairs of variables with negative significant correlation were: K and Shannon's diversity index ($P<0.01$); total nitrogen and S ($P<0.05$); Index of Dominance and Evenness ($P<0.05$).

4.2.6 Beneficiaries' Perception about Environmental Impacts of Social Forestry

4.2.6.1 Respondents' Perception about Impacts of Social Forestry on Soil Fertility and Prevention of Soil Erosion

Opinion of respondents was sought about the impact of SF projects on soil fertility and prevention of soil erosion. In case of soil fertility 58.3% of the respondents opined for no change, 32.5% of the respondents opined for positive change and 9.2% of the respondents opined for negative change. Respondents' perception about prevention of soil erosion was rather good. More than half of the respondents (51.7%) mentioned that due to SF intervention, soil erosion had lessened. About 36% of the respondents opined in favour of no change and 12.5% of the respondents mentioned soil erosion had increased due to SF intervention (Figure 4.2).

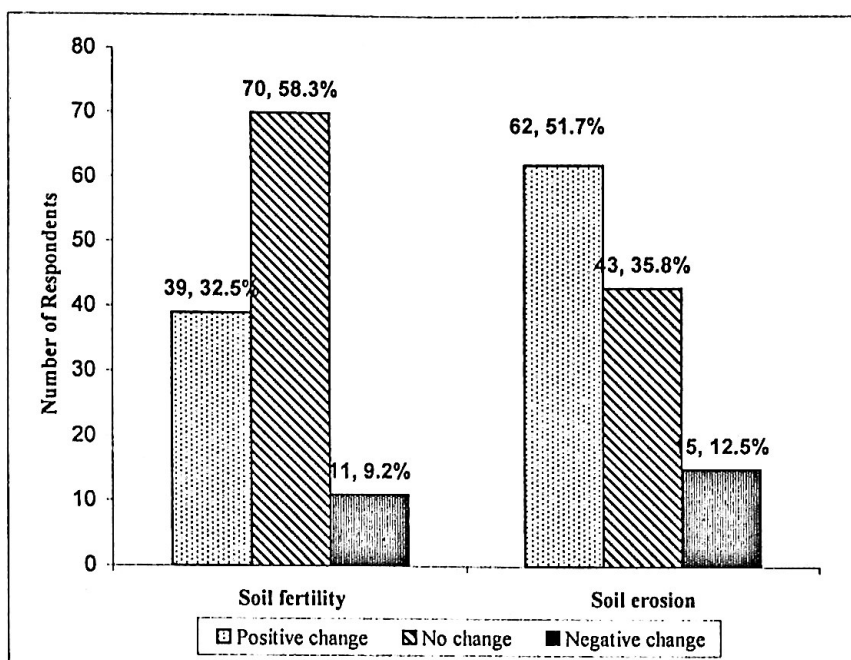


Figure 4.2 Respondents' perception about impacts of Social Forestry on soil fertility and prevention of soil erosion

4.2.6.2 Respondents' Perception about Impact of Social Forestry on Temperature

Temperatures of summer and winter seasons in the HBT are extreme in comparison to other parts of Bangladesh. In the winter season, the temperature starts to plunge and turns into cold wave in the last week of December to the first week of January. In summer, relatively high temperatures prevail in this area in May. The weather became awful and unbearable due to heat wave at this time (BMDA, 2003). Respondents were asked to mention the impact SF intervention on temperature. A clear majority of the respondents (81.7%) perceived that the extremity of temperature during the summer season had declined and weather had become more soothing due to massive afforestation. Some of the respondents opined for no impact (12.5%) and negative impact (5.8%) of SF on temperature. Therefore, the result suggests that most of the respondents sensed a positive impact of SF on temperature (Figure 4.3).

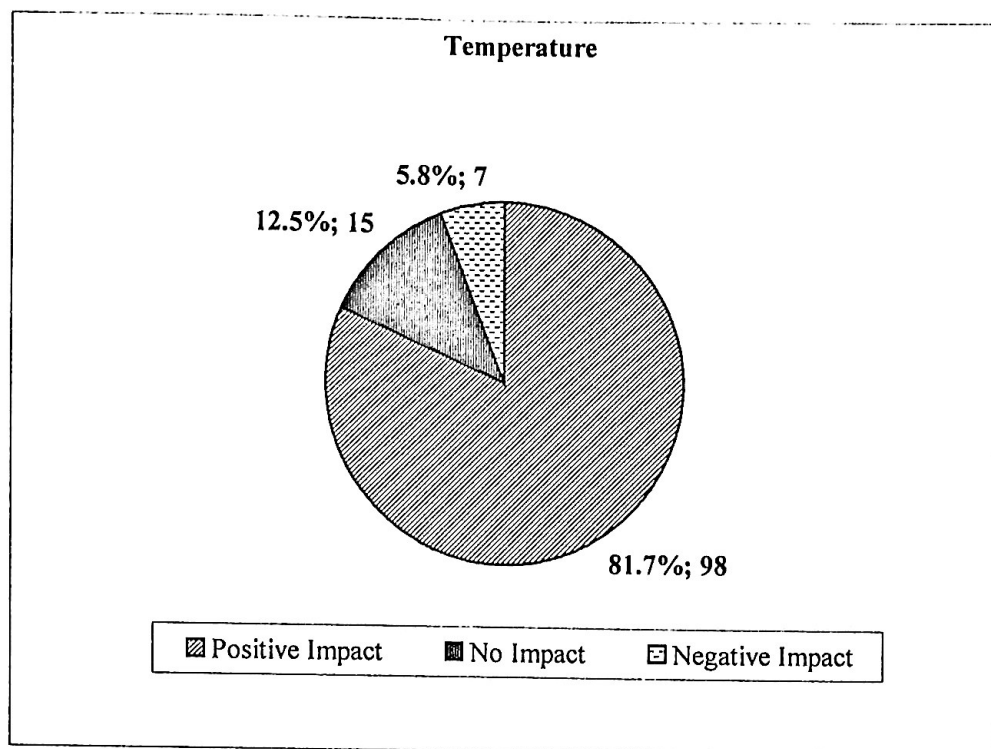


Figure 4.3 Respondents' perception about impact of Social Forestry on temperature

4.2.6.3 Respondents' Perception about Impact of Social Forestry on Rainfall

The annual mean rainfall records of BWDB satiations in the study area (Godagari, Nachol and Manda) during the period of 1980-2002 show that the mean annual rainfall observed in the three stations were 1416 ± 55.45 mm, 1506 ± 79.32 mm and 1463.35 ± 57.67 mm respectively (Appendix B). A study conducted by Ahmed (as cited in MOEF, 2002) reveals that the mean annual rainfall of Barind area has increased from 1374.6 mm in the past (1902-1974) to 1491.1mm during the period of 1975 to 1993. Respondents were asked to mention the impact of SF on rainfall. More than half of the respondents (52.5%) opined that massive afforestation by the FD and NGOs in the study area had contributed to the improvement of the rainfall situation while 29.2% and 18.3% of the respondents opined for no change of rainfall and decrease of rainfall respectively (Figure 4.4).

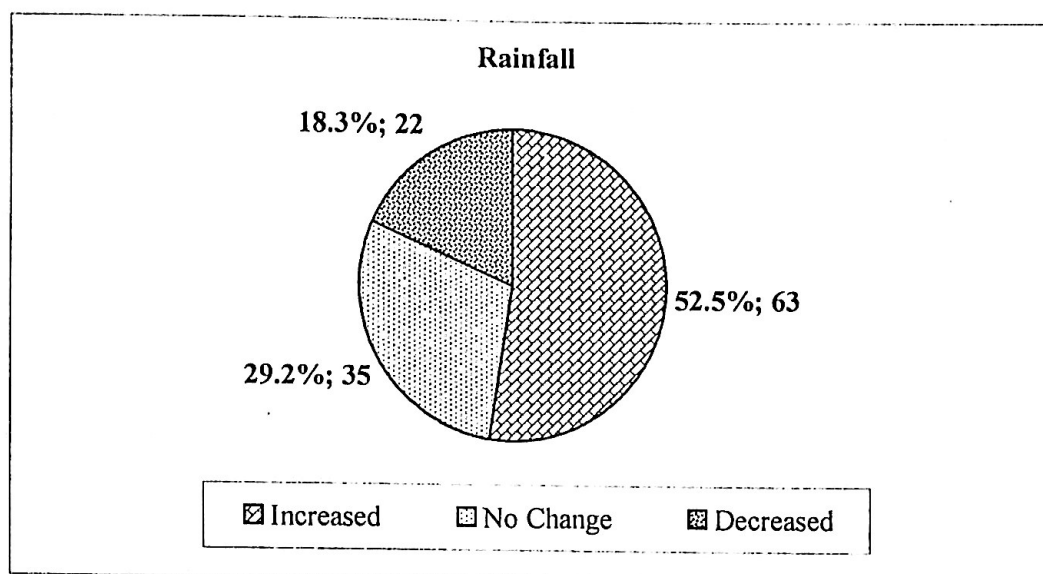


Figure 4.4 Respondents' perception about impact of Social Forestry on rainfall

4.2.6.4 Respondents' Perception about Impacts of Social Forestry on Diversity of Different Plant Groups

The general perception of the respondents about the role of SF in facilitating diversity of different plant groups was not so positive. Although 100% respondents admitted that the number of trees had noticeably increased due to SF. Respondents were asked to mention the impacts of SF on the diversity of different plant groups, namely grass, herb, climber, shrub and tree. It was found that more than 50% of the respondents did not perceive any impact. In case of grass and tree, 29.2% and 34.2% of the respondents opined respectively that SF had positive impacts on the diversity of these two plant groups (Table 4.6).

Table 4.6: Respondents' Perception about Impacts of Social Forestry on Diversity of Different Plant Groups

Plant Group	Positive impact Percent (N)	No impact Percent (N)	Negative impact Percent (N)
Grass	29.2 (35)	50.8(61)	20(24)
Herb	19.2(23)	51.7(62)	29.2(35)
Climber	17.5(21)	57.5(69)	25(30)
Shrub	15(18)	55.8(67)	29.2(35)
Tree	34.2(41)	53.3(64)	12.2(15)

4.2.6.5 Respondents' Perception about Impacts of Social Forestry on Number and Diversity of Birds

└ Birds are the indicators of healthy environment. Bangladesh is rich in avifaunal diversity. Approximately 650 species of Birds have been recorded so far in the country. The bio-geographic location of Bangladesh is in between Indo-Himalayas and Indo-Chinese sub-regions in the orient and the country belongs to an amazing variety of wilderness areas ranging from mangroves in the coast up to evergreen forests of the Chittagong Hill Tracts, which facilitates to accommodate such diverse avifauna (Gain, 1998b). Regarding the impact of SF on number of birds, 13.3%, 25% and 61.7% of the respondents opined for the positive impact, no impact and negative impact respectively. In case of the impact of SF on diversity of birds, 11.7%, 24.2% and 64.2% of the respondents opined for the positive impact, no impact and negative impact respectively. Some respondents also mentioned that afforested exotic sterile trees without flower and fruit were not bird-friendly and the massive plantations of these trees were partly responsible for the decline of number and diversity of birds (Figure 4.5).

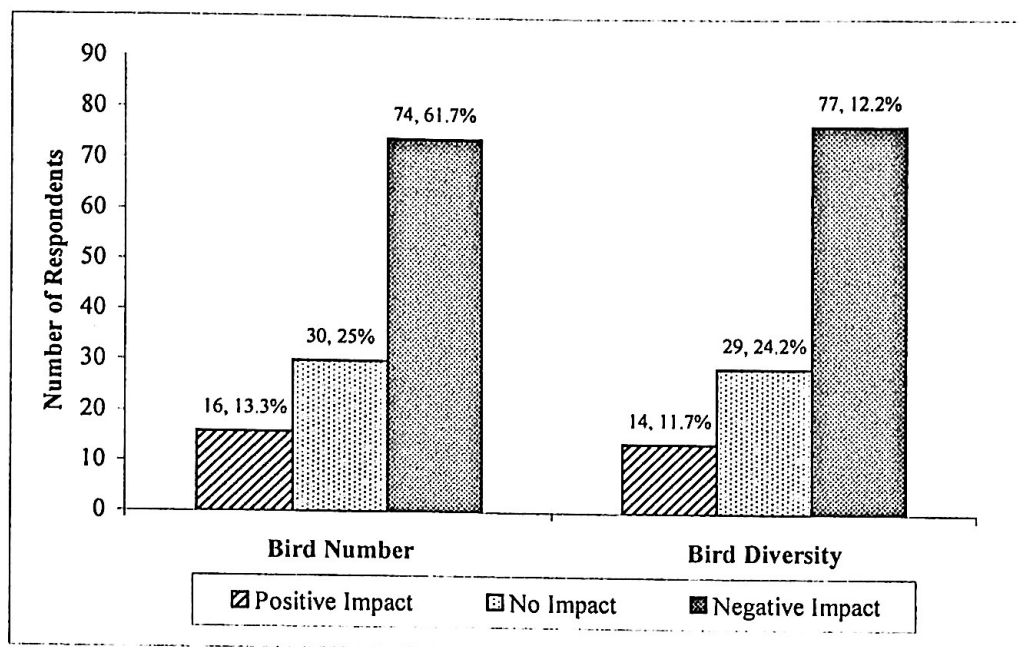


Figure 4.5 Respondents' perception about impacts of Social Forestry on number and diversity of birds

4.3 Discussion

4.3.1 Effect of Plantation on Soil Properties

The content of high organic matter is one of the characteristics of good soil. Any soil having more than 3.5% organic matter content is considered as good soil. The soil of the HBT contains less than 1.0% organic matter (Karim and Iqbal, 2001) and the soil is mostly acidic (p^H 5.0-6.5) in nature. To ameliorate soil fertility, extensive afforestation activities under different SF projects were carried out in the HBT. As a resource management system, SF entails a very close interaction with three interdependent elements such as land, people and technology at a particular time and space (Salehuddin and Rubugio, 1988). Afforestation/Plantation forestry is seemed as a technology in SF. Such technology should be judiciously applied while restoring a fragile ecosystem. Plantations can improve soil attributes of the poorest soil than agricultural crops. However, proper utilisation of plantations and proper management practices are necessary to improve soil attributes as well as to continue nutrient cycling (Silva, 1973). Plantations can improve impoverish and often nutrient-poor soils of degraded lands by reducing bulk density, increasing the availability of nutrients and accumulating more organic material through litter fall and root turn over (Lugo, 1992; Parrotta, 1992). In this study, non-plantation lands adjacent to the plantation sites were considered as reference or control sites. The positive changes of soil attributes of the plantation sites were considered as the effect of plantation on the soil. The trend found across all of the Plantation Soils (PSs) was the success of plantation in improving soil fertility parameters, but the improving trend was species dependent. Some soil fertility parameters such as: organic matter, total nitrogen, K, B, Mn, and Zn were found higher in the PSs than their respective reference soils (Table 4.1). On the other hand, all of the PSs recorded negative changes in some attributes, but the negative trend was conspicuous in the PS of *Acacia auriculiformis* A cunn. ex Benth and the soil recorded negative changes in pH, Ca, P, S, B and Cu (Table 4.2). The results of t-Test showed

that the PSs and reference soils in the three sites showed significant differences in total nitrogen, K, Cu at 5% level (Appendix D). These results indicate that improvement of soil's physico-chemical conditions through plantation depend on the plantation species planted on a particular area.

4.3.2 Comparison of Effects Caused by Exotic and Native-mixed Plantations on Soil Properties

It was evident from the previous section that the direction and magnitude of changes of soil fertility parameters were species dependent. Findings of some researchers support that nutrient cycling capacity and nutrient use efficiency is species-dependant that causes differential impacts on soil attributes (Cuevas and Lugo, 1998; Montagnini, 2001). The soil attributes of native-mixed plantation (site C) were changed significantly than the exotic plantations. Among the three plantation sites, the soil of native-mixed plantation showed the highest percentage of positive changes in organic matter (101%), Ca (35.87%), Mg (50%), total nitrogen (107.14%), B (170.27%), Fe (31.41%) and Zn (124.64%) and showed the second highest changes in Mn (76.06%). On the other hand, the soil of *Dalbergia sissoo* Roxb. plantation (site A) showed the least percentage of positive changes compared to soil of native-mixed plantation (site C) and the soil of *Acacia auriculiformis* A. Cunn. ex Benth. plantation (site B). The soil of *Acacia auriculiformis* A. Cunn. ex Benth. plantation showed the highest percentage of positive changes in K and Mn and least percentage of positive changes in organic matter and total nitrogen. However, some of the soil parameters: pH, Ca, P, S, Cu in the soil of *Acacia auriculiformis* A. Cunn. ex Benth. plantation (site B); Mg, Cu, Fe in the soil of *Dalbergia sissoo* Roxb. plantation (site A); S, Cu, in the soil of native-mixed plantation (site C) showed negative changes than their respective Non-Plantation Soils (Table 4.2). The result demonstrated that the soil of site C had been changed positively far better than the soil of site A and site B.

These differential changes of soil fertility parameters may be attributed to the litter quantity and quality and its influence on chemical and biological activities of soil, and root activities of the overstorey plantation species. Furthermore, the degree of depletion of some attributes in the soil of exotic monocultures (site A, site B) was higher than the soil of native-mixed plantation (site C). This result was consistent with the study of National Conservation Strategy Implementation Project (Bangladesh National Herbarium, 2001). Therefore, proper species selection for plantation plays an important role in restoration of a nutrient poor/degraded land. Ecological zone oriented species selection, long-term local knowledge, local culture, usage of local plant resources, economic and environmental benefits should be considered while selecting a species for plantation into a specific ecological zone. The result showed that the conclusion on whether soil fertility decline or improve in a plantation site differs considerably on the species planted and the ecosystem used for the plantation. The native-mixed plantation species were well suited for the soil improvement conversely *Dalbergia sissoo* Roxb. and *Acacia auriculiformis* A. Cunn. ex Benth. can be judged as unfit for the soil improvement in the High Barind Tract. Moreover, since 1996, *Sissoo* (*Dalbergia sissoo* Roxb.) trees of 10-15 years old have been reported to be dying from dieback disease. This phenomenon is widespread all over the north-west Bangladesh. A study conducted by Bangladesh Forest Research Institute (BFRI) in 2001 revealed that on an average 43 per cent of *Sissoo* (*Dalbergia sissoo* Roxb.) trees had died in 16 districts (The Independent, 2002). This has raised the question about the economic viability of the species. *Acacia auriculiformis* A. Cunn. ex Benth. is considered as a high litter producing species (Drechel, Glaser and Zech, 1991; Duguma and Tonye, 1994). High biomass production appeared to be responsible for soil acidification and negative changes of Ca content than its Non-Plantation Soil

(Table 4.3). The result showed that the soil of *Acacia auriculiformis* A cunn. ex Benth. plantation was turned into strongly acidic soil (pH 4.83) than its reference soil. Several studies report that afforestation with conifer as well as broadleaf species often causes a decrease in pH due to greater acidity of the litter relative to the native vegetation (Essex and Williams, Rhodes and Binkley, as cited in Farley and Kelly, 2004). Gupta (2000) suggests that strongly acidic soils (pH 4-5) cause high and toxic concentrations of soluble Aluminium and Manganese. The staggering positive change of Mn (306.06%) in the soil of site B appeared to be the result of acidification of the soil. The soil of the HBT is acidic in nature, *Acacia auriculiformis* A cunn. ex Benth. seems to be a imperfect plantation species for the amelioration of soil fertility and supporting the flora of the study area. The accumulation of low soil organic matter in site B substantiates the unsuitability of *Acacia auriculiformis* A cunn. ex Benth. as a soil ameliorating plantation species in the HBT. The thick leathery consistent and high tannin content of its litter and poor decomposition-facilitating environment probably attributed to the low soil organic matter accumulation in the *Acacia auriculiformis* A cunn. ex Benth. plantation site .

4.3.3 Floristic Composition

Phytogeographically the study area falls under tropical monsoon climate (Puri, 1960). Due to local climatic and environmental features, the study area bears the symptom of arid to semi arid characteristics. Intense variability of rainfall and temperature, scanty vegetation, gradual desertification and land degradation due to aridity are the main environmental complications of the study area (Khan, 2002; MOEF, 2002). Plantation forests established on degraded lands long devoid of a native tree cover can act as successional catalysts. Plantations can facilitate the recolonisation

of native flora through their influence on understorey microclimate and soil fertility; suppression of dominant grasses and provision of habitats for seed dispersing animals (Parrotta, 1995). Attempt was taken to record the floristic composition of understorey flora of socially afforested plantation sites in view to find out the impact of different overstorey species on the understorey flora and soil attributes. A total of 57 species belonged to 25 families were recorded in the three sites during the study period. Among the recorded species, 1 was climber, 41 were herbs, 6 were shrubs and 9 were tree seedlings (Appendix E). Bangladesh National Herbarium reported 143 angiospermic species in the Barind tract in a detailed investigation on the status of flora (Bangladesh National Herbarium, 2001). Rahman, Ahamed, and Sajjad (1980), Hossain (2004), and Kamruzzaman (2005) recorded 46, 95, and 56 species of herbs, shrubs and climbers respectively in the Rajshahi metropolitan area. All of the three studies reported the spatial and seasonal variations in distribution of plant species. A study conducted by Islam, Rahman, Hossain and Hoque (2001) at four different habitats of Jahangirnagar University found that the vegetation of woodland was more diverse than the vegetation of scrubland, grassland and rice field and 154, 111, 80 and 60 species were recorded respectively on these four habitats.

The understorey flora of the three plantation sites (site A, site B and site C) were dominated by a few abundant species, while most of the species were seldom or rarely present. The total numbers of plant species were 26, 30 and 42 in site A, site B, and site C respectively (Table 4.3). Among them 9 species were found Common in the three sites during the study period (Appendix E). The total number of species and total number of individual plants were, however found to vary from season to season in all the sites. The differences in the total number of species and total number of individual plants were maximum during the rainy season and minimum during the winter season (Appendix I).

Gafur, Karim and Khan (1978) reported that the difference in species composition and the dominance of plants were found to be related with moisture status of the soil. Sing (1979) observed that the maximum number of plants was found in the rainy season and the seasonal variability depended on biotic stresses.

Site A: As regards the dominance and regular distribution of the species, it was observed that in site A, *Brachiaria sp* and *Evolvulus nummularius* L. were regularly distributed during the three seasons. These species were constantly present in the site and according to IVI of the species in site A they were the dominant species in all the three seasons. During the rainy season, *Croton bonplandianum* Bail., *Achyranthes aspera* L., *Sida cordifolia* L. and *Oplismenus compositus* (L.) P. Beauv. were constantly or mostly present and competing species. During the winter season, *Achyranthes aspera* L. was constantly present, *Sida cordifolia* L. was mostly present and they were competing species. In the summer season, *Achyranthes aspera* L., *Croton bonplandianum* Bail., *Digitaria sanguinalis* (L.) Scop and *Sida acuta* Burm. were the competing species and they were constantly or mostly present in the site (Tables 4.7- 4.9).

Site B: During the rainy season *Oplismenus compositus* (L.) P. Beauv. and *Brachiaria sp* were co-dominant species and showed maximum 100% frequency value. According to IVI of the species in site B these two species were the dominant species. Among the competing species *Hemigraphis hirta* T. Anders., *Cynodon dactylon* Pers. and *Croton bonplandianum* Bail. were noteworthy, and they were constantly present in the site. During the winter season, *Cynodon dactylon* Pers. and *Evolvulus nummularius* L. were the two dominant species. In the summer season, *Isachne miliacea* Roth. and *Eleusine indica* (L.) Gaertn. were constantly present. According to IVI values, they were the co-dominant species in the site and *Evolvulus nummularius* L. and *Cynodon dactylon* Pers. were the competing species (Tables 4.10- 4.12).

Site C: In this site, *Eleusine indica* (L.) Gaertn. and *Evolvulus nummularius* L. were found to be dominant species in all the three seasons. These species were constantly present in the site and according to IVI of all of the species in site C they were the two dominant species in all the three seasons. During the rainy season *Desmodium triflorum* (L.) DC., *Ichnanthus vicinus* (Bail) Merr., *Oplismenus compositus* (L.) P. Beauv. and *Echinochloa colonum* (L.) Link. were constantly or mostly present as competing species. During the winter season, most of the species showed relatively low frequency values except *Nelsonia campestris* R. Br. and *Achyranthes aspera* L. and they were often present in the site. In the summer season, most of species were rarely or seldom occurring with low frequency values. Only *Dichanthium annulatum* (Forsk.) Stapf. and *Cyperus rotundus* L. were often present in site C (Tables 4.13-4.15).

Another useful parameter computing the importance of individual species is relative abundance. It is a useful measure when it is important to know how a population is changing (Odum, 1971). In site A, *Brachiaria sp* and *Evolvulus nummularius* L. were co-dominant species and their relative abundance values were 18.1 and 23.2 during the rainy season, 28.6 and 24.9 during the winter season, and 27.9 and 22.5 during the summer season respectively (Table 4.7b, Table 4.8b, Table 4.9b). In site B, during the rainy season, the two dominant species were *Oplismenus compositus* (L.) P. Beauv. and *Brachiaria sp* and their relative abundance values were 24.7 and 14.6 respectively. In the winter season, relative abundance values of two dominant species- *Cynodon dactylon* Pers. and *Evolvulus nummularius* L. were 26.9 and 23 respectively. During the summer season, *Isachne miliacea* Roth. and *Eleusine indica* (L.) Gaertn. were dominant species and they showed relative abundance values of 40.9 and 12.5 respectively (Table 4.10b, Table 4.11b, Table 4.12b). In site C, *Eleusine indica* (L.)

Gaertn. and *Evolvulus nummularius* L. were found to be dominant species in all the three seasons and their relative abundance values were 13.8 and 11.7 during the rainy season, 25.7 and 14.5 during the winter season and 16.5 and 18.2 during the summer season respectively (Table 4.13b, Table 4.14b, Table 4.15b).

It is evident from the analytic characteristics of the understorey plant communities of three sites that, the presence of tree seedlings, shrubs and climbers were scanty and only herbaceous plants (in the ground layer) dominated these understorey plant communities. Although the three sites were dominated by herbaceous species, their floristic composition was different from each other. The floristic similarity among the three possible pairs of plant communities was comparatively low. Jaccard's community co-efficient among the three pairs of communities varied from 27.27% to 41.67%. The understorey plant communities of site A and site C showed the highest similarity of 41.67%, and the lowest similarity was found between the understorey plant communities of site A and site B (Table 4.4). Ramvos and Roberts (2000) report that overstorey canopy composition, stand structure characteristics, microenvironment of a plantation stand are important to understorey diversity and composition. The variations of analytic and synthetic characteristics of the understorey plant communities in the three sites may be attributed to the overstorey vegetation structure, and quality and quantity of litter fall from the overstorey vegetation, which have an important role in changing the edaphic characteristics of the sites

4.3.4 Phytodiversity

The results showed that the understorey flora of site C was more diverse and rich in species composition. The results of ANOVAs revealed that the number of species showed significant difference at 5% level in case of sites and seasons (Appendix I). The Shannon's diversity index and evenness values of site C were the highest among the three sites. The index of dominance was the highest in site A and the lowest in site C. The results indicated that both diversity and evenness behaved inversely to the index of dominance (Table 4.5), which supports the view of Odum (1971). The results of the correlation analysis revealed that there was a negative correlation between index of dominance and evenness. A positive correlation was found between organic matter of soil and number of species, and a very significant ($P < 0.01$) negative correlation was found between Shannon's diversity index and K (Appendix K). None of the understorey plant communities surveyed in the three sites was a primary climax. They were rather early stages of succession. More advance the successional stage higher the plant species diversity (Odum 1971; Khanduri, Baduni, and Sharma 1997). As site A and site B were earlier successional stages than site C, the diversity values were lesser in site A and site B. The results revealed that understorey plant community of site C was to some extent more stable than site A and site B. The results of the correlation analysis between some phytosocial parameters of the understorey flora and edaphic parameters of the sites substantiate the role of overstorey species to the composition, density and diversity of understorey species. The variation of the understorey species composition and phyto-diversity in the three sites may be attributed to the overstorey litter quality and quantity and its influence on soil chemical and biological activities, root competition as well as physical characteristics (crown size, density, height etc.) of the overstorey plantation species.

4.3.5 Beneficiaries' Perception Regarding Environmental Impacts of Social Forestry

The perception of respondents pertaining to the environmental impacts of SF revealed that majority of the respondents felt no positive impact of SF about soil fertility and prevention soil erosion (Figure 4.2). Many respondents opined that plantation of exotic species (such as *Eucalyptus sp*, *Acacia auriculiformis* A cunn. ex Benth) accelerated soil degradation and their perception regarding this supported the results of soil analysis of three plantation sites of this study. Overwhelming majority of the respondents (81.7%) felt that the extremity of temperature decreased as compared to pre SF period (Figure 4.3). Just over half of the respondents (52.5%) reported about the increase of rainfall during SF period (Figure 4.4). People's perception about the positive impact of SF on these two important climatic parameters was probably the resultant of massive afforestation in the study area by the FD and NGOs. Majority of respondents perceived that SF in the study area was not able to facilitate the diversity of different plant groups (Table 4.6), although they mentioned the number of trees in the area increased noticeably. Perception about the birds' number and diversity were farther disquieting. More than 60% of the respondents felt SF caused negative impacts on the birds' number and diversity (Figure 4.5). Respondents perceptions about the impacts of SF on the environmental parameters suggests that except temperature and rainfall, the current SF practice has no impact on soil fertility, soil erosion, diversity of different plant groups, birds' number and birds' diversity. Many respondents suggested that if ecological and economic need-based native species were preferred for afforestation rather than exotic monocultures the positive impact of SF on the environmental parameters would have been many folds than the present situation.

Table 4.7a: List of Species with their Number, Frequency, Density and Abundance Values in Site-A (*Dalbergia sissoo* Roxb. plantation stand) during Rainy season (July-October 2003 & 2004)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	NIP	Frequency	Density	Abundance
1	<i>Acacia nilotica</i> L. Del (Seedling)	0.5 $\pm$ 0.4	5.0 $\pm$ 3.4	0.1 $\pm$ 0.04	0.2 $\pm$ 0.2
2	<i>Achyranthes aspera</i> L.	145.5 $\pm$ 6.8	90.0 $\pm$ 4.5	14.6 $\pm$ 0.7	16.4 $\pm$ 0.9
3	<i>Amaranthus spinosus</i> L.	6.5 $\pm$ 2.8	15.0 $\pm$ 6.7	0.7 $\pm$ 0.3	1.8 $\pm$ 0.7
4	<i>Azadirachta indica</i> A. Juss. (Seedling)	3.5 $\pm$ 1.0	15.0 $\pm$ 5.0	0.4 $\pm$ 0.1	2.0 $\pm$ 0.7
5	<i>Brachiaria sp</i>	346.5 $\pm$ 15.1	100.0 $\pm$ 0.0	34.7 $\pm$ 1.5	34.7 $\pm$ 1.5
6	<i>Croton bonplandianum</i> Bail.	52.5 $\pm$ 3.1	95.0 $\pm$ 3.4	5.3 $\pm$ 0.3	5.5 $\pm$ 0.3
7	<i>Cynodon dactylon</i> Pers.	74.5 $\pm$ 5.4	45.0 $\pm$ 6.7	7.5 $\pm$ 0.5	19.5 $\pm$ 2.6
8	<i>Dalbergia sissoo</i> Roxb. (Seedling)	1.0 $\pm$ 0.4	10.0 $\pm$ 3.7	0.1 $\pm$ 0.04	0.6 $\pm$ 0.2
9	<i>Desmodium triflorum</i> (L.) DC.	15.5 $\pm$ 4.3	10.0 $\pm$ 2.6	1.6 $\pm$ 0.4	8.8 $\pm$ 2.5
10	<i>Eleusine indica</i> (L.) Gaertn.	12.5 $\pm$ 4.4	20.0 $\pm$ 7.5	1.3 $\pm$ 0.4	3.6 $\pm$ 1.4
11	<i>Eragrostis tenella</i> (L.) P. Baeuv.	8.0 $\pm$ 2.9	20.0 $\pm$ 7.1	0.8 $\pm$ 0.3	2.1 $\pm$ 0.7
12	<i>Eragrostis unioides</i> (Retz.) Nees.	24.5 $\pm$ 2.3	50.0 $\pm$ 7.9	2.5 $\pm$ 0.2	5.5 $\pm$ 0.6
13	<i>Evolvulus nummularius</i> L.	422.5 $\pm$ 20.2	95.0 $\pm$ 3.4	42.3 $\pm$ 2.0	44.4 $\pm$ 1.1
14	<i>Flacourtia indica</i> (Brum. f.) Merr.	1.0 $\pm$ 0.3	10.0 $\pm$ 3.0	0.1 $\pm$ 0.0	0.8 $\pm$ 0.2
15	<i>Ichnanthus vicinus</i> (Bail) Merr.	11.5 $\pm$ 4.1	35.0 $\pm$ 12.5	1.2 $\pm$ 0.4	1.7 $\pm$ 0.6
16	<i>Oplismenus compositus</i> (L.) P. Beauv.	106.5 $\pm$ 11.5	65.0 $\pm$ 9.0	10.7 $\pm$ 1.2	17.5 $\pm$ 1.2
17	<i>Paspalidium flavidum</i> (Retz.) A. Camus	55.5 $\pm$ 2.2	60.0 $\pm$ 5.8	5.6 $\pm$ 0.2	9.9 $\pm$ 0.9
18	<i>Sida cordifolia</i> L.	137.5 $\pm$ 5.9	80.0 $\pm$ 6.7	13.8 $\pm$ 0.6	18.1 $\pm$ 1.4
	Total	1425.5$\pm$93.0	820.0$\pm$98.8	142.6$\pm$2.1	192.9$\pm$17.6

NIP= Number of individual plants

Table 4.7b: List of Species with their Relative frequency, Relative density, Relative abundance and Importance Value Index (IVI) in Site-A (*Dalbergia sissoo* Roxb. plantation stand) during Rainy season (July- October 2003 & 2004).

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	Relative frequency	Relative density	Relative abundance	IVI
1	<i>Acacia nilotica</i> L. Del (Seedling)	0.5 $\pm$ 0.4	0.03 $\pm$ 0.03	0.1 $\pm$ 0.1	0.7 $\pm$ 0.5
2	<i>Achyranthes aspera</i> L.	11.3 $\pm$ 0.9	10.2 $\pm$ 0.5	8.5 $\pm$ 0.4	30 $\pm$ 1.2
3	<i>Amaranthus spinosus</i> L.	1.6 $\pm$ 0.7	0.5 $\pm$ 0.2	0.9 $\pm$ 0.4	3 $\pm$ 1.2
4	<i>Azadirachta indica</i> A. Juss. (Seedling)	1.9 $\pm$ 0.7	0.2 $\pm$ 0.1	1.1 $\pm$ 0.3	3.2 $\pm$ 0.8
5	<i>Brachiaria sp</i>	12.4 $\pm$ 0.6	24.3 $\pm$ 1	18.1 $\pm$ 1	54.8 $\pm$ 2
6	<i>Croton bonplandianum</i> Bail.	11.8 $\pm$ 0.6	3.7 $\pm$ 0.2	2.9 $\pm$ 0.1	18.3 $\pm$ 0.7
7	<i>Cynodon dactylon</i> Pers.	5.6 $\pm$ 0.9	5.2 $\pm$ 0.4	9.9 $\pm$ 1.2	20.7 $\pm$ 1
8	<i>Dalbergia sissoo</i> Roxb. (Seedling)	1.2 $\pm$ 0.4	0.1 $\pm$ 0	0.3 $\pm$ 0.1	1.5 $\pm$ 0.5
9	<i>Desmodium triflorum</i> (L.) DC.	1.2 $\pm$ 0.3	1.1 $\pm$ 0.3	4.4 $\pm$ 1.2	6.8 $\pm$ 1.6
10	<i>Eleusine indica</i> (L.) Gaertn.	2.1 $\pm$ 0.8	0.9 $\pm$ 0.3	1.8 $\pm$ 0.7	4.8 $\pm$ 1.6
11	<i>Eragrostis tenella</i> (L.) P. Baeuv.	2.2 $\pm$ 0.8	0.6 $\pm$ 0.2	1 $\pm$ 0.4	3.8 $\pm$ 1.3
12	<i>Eragrostis unioloides</i> (Retz.) Nees.	6.1 $\pm$ 1	1.7 $\pm$ 0.2	2.9 $\pm$ 0.3	10.8 $\pm$ 1
13	<i>Evolvulus nummularius</i> L.	11.9 $\pm$ 0.8	29.6 $\pm$ 1.3	23.2 $\pm$ 0.8	64.7 $\pm$ 2.7
14	<i>Flacourtia indica</i> (Brum. f.) Merr.	1.2 $\pm$ 0.4	0.1 $\pm$ 0.02	0.4 $\pm$ 0.1	1.7 $\pm$ 0.4
15	<i>Ichnanthus vicinus</i> (Bail) Merr.	3.9 $\pm$ 1.4	0.8 $\pm$ 0.3	0.9 $\pm$ 0.3	5.5 $\pm$ 1.9
16	<i>Oplismenus compositus</i> (L.) P. Beauv.	7.7 $\pm$ 0.8	7.5 $\pm$ 0.8	9.1 $\pm$ 0.6	24.3 $\pm$ 1.2
17	<i>Paspalidium flavidum</i> (Retz.) A. Camus	7.3 $\pm$ 0.6	3.9 $\pm$ 0.1	5.2 $\pm$ 0.5	16.4 $\pm$ 0.5
18	<i>Sida cordifolia</i> L.	10 $\pm$ 1	9.6 $\pm$ 0.3	9.4 $\pm$ 0.6	29 $\pm$ 1
	Total	100$\pm$ 13	100$\pm$ 6.3	100$\pm$ 9.2	300$\pm$ 21.2

Table 4.8a: List of Species with their Number, Frequency, Density and Abundance Values in Site-A (*Dalbergia sissoo* Roxb. Plantation Stand) during Winter Season (November- February 2003-2004 & 2004-2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	NIP	Frequency	Density	Abundance
1	<i>Achyranthes aspera</i> L.	59 $\pm$ 8.2	85 $\pm$ 3.73	5.9 $\pm$ 0.8	6.9 $\pm$ 0.9
2	<i>Azadirachta indica</i> A. Juss. (Seedling)	2.5 $\pm$ 0.5	15 $\pm$ 3.4	0.3 $\pm$ 0.1	1.5 $\pm$ 0.3
3	<i>Brachiaria</i> sp	287 $\pm$ 58.6	90 $\pm$ 5.6	28.7 $\pm$ 5.9	30.6 $\pm$ 5.3
4	<i>Croton bonplandianum</i> Bail.	19 $\pm$ 4.9	60 $\pm$ 9.4	1.9 $\pm$ 0.5	2.9 $\pm$ 0.4
5	<i>Cynodon dactylon</i> Pers.	64.5 $\pm$ 22	40 $\pm$ 13.9	6.5 $\pm$ 2.2	8.4 $\pm$ 2.9
6	<i>Dalbergia sissoo</i> Roxb.(Seedling)	5.5 $\pm$ 2	10 $\pm$ 3.9	0.6 $\pm$ 0.2	4.5 $\pm$ 1.7
7	<i>Eleusine indica</i> (L.) Gaertn.	25.5 $\pm$ 10.9	15 $\pm$ 5.6	2.6 $\pm$ 1.1	8.2 $\pm$ 3.1
8	<i>Evolvulus nummularius</i> L.	228.5 $\pm$ 17.9	100 $\pm$ 0	22.9 $\pm$ 1.8	22.9 $\pm$ 1.8
9	<i>Sida cordifolia</i> L.	92 $\pm$ 9	75 $\pm$ 7.6	9.2 $\pm$ 0.9	14.5 $\pm$ 2.7
	Total	783.5$\pm$ 134	490$\pm$ 53.3	78.4$\pm$ 13.4	100.1$\pm$ 19.3

NIP= Number of individual plants

Table 4.8b: List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-A (*Dalbergia sissoo* Roxb. Plantation Stand) during Winter Season (November- February 2003-2004 & 2004-2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	Relative frequency	Relative density	Relative abundance	IVI
1	<i>Achyranthes aspera</i> L.	18.2 $\pm$ 1.6	9 $\pm$ 1.8	8 $\pm$ 1.5	35.2 $\pm$ 4.8
2	<i>Azadirachta indica</i> A. Juss. (Seedling)	3.4 $\pm$ 0.8	0.4 $\pm$ 0.1	1.6 $\pm$ 0.4	5.4 $\pm$ 1.2
3	<i>Brachiaria</i> sp	18.7 $\pm$ 1.2	33.2 $\pm$ 4.4	28.6 $\pm$ 3	80.5 $\pm$ 6.7
4	<i>Croton bonplandianum</i> Bail.	11.7 $\pm$ 1.4	2.1 $\pm$ 0.4	2.8 $\pm$ 0.3	16.7 $\pm$ 1.8
5	<i>Cynodon dactylon</i> Pers.	6.9 $\pm$ 2.3	6.4 $\pm$ 2.2	6.6 $\pm$ 2.3	19.9 $\pm$ 6.7
6	<i>Dalbergia sissoo</i> Roxb.(Seedling)	2.1 $\pm$ 1	0.6 $\pm$ 0.2	3.7 $\pm$ 1.4	6.4 $\pm$ 1.9
7	<i>Eleusine indica</i> (L.) Gaertn.	2.6 $\pm$ 1	2.5 $\pm$ 1	6.3 $\pm$ 2.3	11.4 $\pm$ 4.2
8	<i>Evolvulus nummularius</i> L.	21.3 $\pm$ 1.5	32.1 $\pm$ 4	24.9 $\pm$ 3	78.2 $\pm$ 8.3
9	<i>Sida cordifolia</i> L.	15.2 $\pm$ 1.1	13.7 $\pm$ 2.4	17.4 $\pm$ 4.2	46.3 $\pm$ 6.2
	Total	100$\pm$ 11.9	100$\pm$ 16.5	100$\pm$ 18.4	300$\pm$ 41.7

Table 4.9a: List of Species with their Number, Frequency, Density and Abundance Values in Site-A (*Dalbergia sissoo* Roxb. Plantation Stand) during Summer Season (March- June 2004 & 2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	NIP	Frequency	Density	Abundance
1	<i>Achyranthes aspera</i> L.	116 $\pm$ 15.4	85 $\pm$ 6.5	11.6 $\pm$ 1.5	13.4 $\pm$ 1.1
2	<i>Alysicarpus vaginalis</i> DC.	5 $\pm$ 1.8	10 $\pm$ 3.7	0.5 $\pm$ 0.2	2.8 $\pm$ 1.1
3	<i>Azadirachta indica</i> A. Juss. (Seedling)	3.5 $\pm$ 0.7	25 $\pm$ 4.8	0.4 $\pm$ 0.1	1.7 $\pm$ 0.3
4	<i>Brachiaria sp</i>	281 $\pm$ 82.2	85 $\pm$ 6.5	28.1 $\pm$ 8.2	28.9 $\pm$ 7.9
5	<i>Croton bonplandianum</i> Bail.	31.5 $\pm$ 2.9	80 $\pm$ 4.5	3.2 $\pm$ 0.3	4 $\pm$ 0.4
6	<i>Dalbergia sissoo</i> Roxb. (Seedling)	2.5 $\pm$ 0.3	25 $\pm$ 3.4	0.3 $\pm$ 0	1.2 $\pm$ 0.3
7	<i>Digitaria sanguinalis</i> (L.) Scop.	119.5 $\pm$ 32	70 $\pm$ 10.2	12 $\pm$ 3.2	13.9 $\pm$ 2.6
8	<i>Echinochloa colonum</i> (L.) Link	0.5 $\pm$ 0.3	5 $\pm$ 3.4	0.1 $\pm$ 0	0.2 $\pm$ 0.1
9	<i>Eleusine indica</i> (L.) Gaertn.	0.5 $\pm$ 0.3	5 $\pm$ 1.7	0.1 $\pm$ 0	0.5 $\pm$ 0.3
10	<i>Evolvulus nummularius</i> L.	224 $\pm$ 4.7	100 $\pm$ 0	22.4 $\pm$ 0.5	22.4 $\pm$ 0.5
11	<i>Flacourtia indica</i> (Brum. f.) Merr.	0.5 $\pm$ 0.3	5 $\pm$ 2.2	0.1 $\pm$ 0.03	0.4 $\pm$ 0.2
12	<i>Imperata cylindrica</i> (L.) P. Beauv.	55.5 $\pm$ 18.6	40 $\pm$ 13.6	5.6 $\pm$ 1.9	7 $\pm$ 2.4
13	<i>Sida acuta</i> Burm.	8.5 $\pm$ 2.9	40 $\pm$ 13.6	0.9 $\pm$ 0.3	1.1 $\pm$ 0.4
14	<i>Solanum nigrum</i> L.	3 $\pm$ 1.2	10 $\pm$ 3.9	0.3 $\pm$ 0.1	1.6 $\pm$ 0.6
15	<i>Vetiveria zizanioides</i> (L.) Nash	0.5 $\pm$ 0.4	5 $\pm$ 4	0.1 $\pm$ 0.04	0.2 $\pm$ 0.1
16	<i>Zizyphus mauritiana</i> Lamk. (Seedling)	0.5 $\pm$ 0.3	5 $\pm$ 3.1	0.1 $\pm$ 0.03	0.3 $\pm$ 0.2
	Total	852.5$\pm$164.4	595.0$\pm$85.1	85.3$\pm$16.4	99.7$\pm$18.6

NIP= Number of individual plants

Table 4.9b: List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-A (*Dalbergia sissoo* Roxb. Plantation Stand) during Summer Season (March- June 2004, & 2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	Relative frequency	Relative density	Relative abundance	IVI
1	<i>Achyranthes aspera</i> L.	15.7 $\pm$ 2.1	13.2 $\pm$ 1.3	13.4 $\pm$ 0.9	42.3 $\pm$ 3.9
2	<i>Alysicarpus vaginalis</i> DC.	1.4 $\pm$ 0.5	0.7 $\pm$ 0.3	2.9 $\pm$ 1.1	4.9 $\pm$ 1.7
3	<i>Azadirachta indica</i> A. Juss. (Seedling)	4.2 $\pm$ 0.7	0.4 $\pm$ 0.1	1.7 $\pm$ 0.3	6.3 $\pm$ 0.7
4	<i>Brachiaria</i> sp	15.7 $\pm$ 2.1	29.5 $\pm$ 8.2	27.9 $\pm$ 7.5	73.1 $\pm$ 17.7
5	<i>Croton bonplandianum</i> Bail.	13.8 $\pm$ 0.6	3.9 $\pm$ 0.5	4.1 $\pm$ 0.4	21.7 $\pm$ 0.5
6	<i>Dalbergia sissoo</i> Roxb. (Seedling)	4.6 $\pm$ 0.8	0.3 $\pm$ 0.04	1.2 $\pm$ 0.4	6.1 $\pm$ 0.7
7	<i>Digitaria sanguinalis</i> (L.) Scop.	11.2 $\pm$ 0.9	15.9 $\pm$ 4.5	14.4 $\pm$ 2.9	41.5 $\pm$ 8.2
8	<i>Echinochloa colonum</i> (L.) Link	0.7 $\pm$ 0.5	0.1 $\pm$ 0.05	0.2 $\pm$ 0.1	0.9 $\pm$ 0.6
9	<i>Eleusine indica</i> (L.) Gaertn.	0.7 $\pm$ 0.2	0.1 $\pm$ 0.05	0.5 $\pm$ 0.4	1.3 $\pm$ 0.6
10	<i>Evolvulus nummularius</i> L.	17.8 $\pm$ 1.4	26.7 $\pm$ 0.9	22.5 $\pm$ 0.3	66.9 $\pm$ 0.9
11	<i>Flacourtia indica</i> (Brum. f.) Merr.	0.7 $\pm$ 0.3	0.1 $\pm$ 0.04	0.4 $\pm$ 0.2	1.2 $\pm$ 0.5
12	<i>Imperata cylindrica</i> (L.) P. Beauv.	5.5 $\pm$ 1.8	7.6 $\pm$ 2.5	7.4 $\pm$ 2.5	20.4 $\pm$ 6.8
13	<i>Sida acuta</i> Burm.	5.5 $\pm$ 1.9	1.2 $\pm$ 0.4	1.2 $\pm$ 0.4	7.8 $\pm$ 2.6
14	<i>Solanum nigrum</i> L.	1.4 $\pm$ 0.5	0.4 $\pm$ 0.2	1.7 $\pm$ 0.6	3.4 $\pm$ 1.2
15	<i>Vetiveria zizanioides</i> (L.) Nash	0.7 $\pm$ 0.6	0.1 $\pm$ 0.1	0.2 $\pm$ 0.1	1 $\pm$ 0.8
16	<i>Zizyphus mauritiana</i> Lamk. (Seedling)	0.7 $\pm$ 0.4	0.1 $\pm$ 0.04	0.3 $\pm$ 0.2	1.1 $\pm$ 0.6
	Total	100$\pm$ 15.4	100$\pm$ 19.1	100$\pm$ 18.3	300$\pm$ 48

Table 4.10a: List of Species with their Number, Frequency, Density and Abundance Values in Site-B (*Acacia auriculiformis* A cunn. ex Benth. Plantation Stand) during Rainy Season (July-October, 2003 & 2004)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	NIP	Frequency	Density	Abundance
1	<i>Acacia auriculiformis</i> A cunn. ex Benth. (Seedling)	8.5 $\pm$ 1.1	50 $\pm$ 9.1	0.9 $\pm$ 0.1	2 $\pm$ 0.3
2	<i>Alysicarpus vaginalis</i> DC.	50 $\pm$ 6.9	60 $\pm$ 8	5 $\pm$ 0.7	8.5 $\pm$ 0.7
3	<i>Brachiaria</i> sp	244 $\pm$ 13.5	100 $\pm$ 0	24.4 $\pm$ 1.3	24.4 $\pm$ 1.3
4	<i>Cassia sophera</i> L.	1 $\pm$ 0.5	5 $\pm$ 2.2	0.1 $\pm$ 0.05	0.8 $\pm$ 0.4
5	<i>Centella asiatica</i> (L) Urban.	1 $\pm$ 0.5	5 $\pm$ 2.2	0.1 $\pm$ 0.05	0.8 $\pm$ 0.4
6	<i>Croton bonplandianum</i> Bail.	36.5 $\pm$ 3.8	85 $\pm$ 6.7	3.7 $\pm$ 0.4	4.8 $\pm$ 0.8
7	<i>Cynodon dactylon</i> Pers.	117.5 $\pm$ 4.8	85 $\pm$ 4.8	11.8 $\pm$ 0.5	14.1 $\pm$ 0.6
8	<i>Desmodium triflorum</i> (L.) DC.	31.5 $\pm$ 2.5	55 $\pm$ 7.2	3.2 $\pm$ 0.3	6.3 $\pm$ 0.7
9	<i>Eleusine indica</i> (L.) Gaertn.	42.5 $\pm$ 11.2	45 $\pm$ 6.2	4.3 $\pm$ 1.1	9.6 $\pm$ 2.4
10	<i>Euphorbia hirta</i> L.	3 $\pm$ 0.7	15 $\pm$ 3.1	0.3 $\pm$ 0.1	1.8 $\pm$ 0.3
11	<i>Hemigraphis hirta</i> T. Anders.	199.5 $\pm$ 10.7	95 $\pm$ 3.4	20 $\pm$ 1.1	21.1 $\pm$ 0.9
12	<i>Ichnanthus vicinus</i> (Bail) Merr.	20.5 $\pm$ 2.5	25 $\pm$ 3.1	2.1 $\pm$ 0.3	9.6 $\pm$ 2
13	<i>Imperata cylindrica</i> (L.) P. Beauv.	24.5 $\pm$ 3.5	35 $\pm$ 3.4	2.5 $\pm$ 0.4	7.2 $\pm$ 0.9
14	<i>Leucas aspera</i> (Willd.) Link.	3 $\pm$ 0.6	20 $\pm$ 3	0.3 $\pm$ 0.1	1.4 $\pm$ 0.2
15	<i>Mimosa pudica</i> L.	1.5 $\pm$ 0.8	5 $\pm$ 2.7	0.2 $\pm$ 0.1	1 $\pm$ 0.6
16	<i>Ocimum basilicum</i> L.	1.5 $\pm$ 0.6	10 $\pm$ 3.9	0.2 $\pm$ 0.1	0.8 $\pm$ 0.3
17	<i>Oplismenus compositus</i> (L.) P. Beauv.	412.5 $\pm$ 23.7	100 $\pm$ 0	41.3 $\pm$ 2.4	41.3 $\pm$ 2.4
18	<i>Phyllanthus niruri</i> L.	4.5 $\pm$ 0.9	20 $\pm$ 3.9	0.5 $\pm$ 0.1	2.7 $\pm$ 0.8
19	<i>Sida cordifolia</i> L.	16 $\pm$ 3	40 $\pm$ 3.9	1.6 $\pm$ 0.3	4.5 $\pm$ 1.1
20	<i>Sporobolus diander</i> (Retz.) P. Beauv.	15 $\pm$ 1.3	35 $\pm$ 3.4	1.5 $\pm$ 0.1	4.5 $\pm$ 0.4
	Total	1234$\pm$ 93.1	890$\pm$ 80.3	123.4$\pm$ 9.3	167.1$\pm$ 17.4

NIP= Number of individual plants

Table 4.10b: List of Species with their Relative Frequency, Relative Density, Relative Abundance and IVI in Site-B (*Acacia auriculiformis* A cunn. ex Benth. Plantation Stand) during Rainy Season (July- October 2003 &2004)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	Relative frequency	Relative density	Relative abundance	IVI
1	<i>Acacia auriculiformis</i> A cunn. ex Benth. (Seedling)	5.7 $\pm$ 1	0.7 $\pm$ 0.1	1.2 $\pm$ 0.2	7.6 $\pm$ 1
2	<i>Alysicarpus vaginalis</i> DC.	6.8 $\pm$ 1	4 $\pm$ 0.6	5.1 $\pm$ 0.5	16 $\pm$ 1.6
3	<i>Brachiaria</i> sp	11.3 $\pm$ 0.2	19.7 $\pm$ 0.9	14.6 $\pm$ 0.7	45.6 $\pm$ 1.5
4	<i>Cassia sophera</i> L.	0.5 $\pm$ 0.2	0.1 $\pm$ 0	0.5 $\pm$ 0.2	1.1 $\pm$ 0.5
5	<i>Centella asiatica</i> (L) Urban.	0.5 $\pm$ 0.2	0.1 $\pm$ 0	0.5 $\pm$ 0.2	1.1 $\pm$ 0.5
6	<i>Croton bonplandianum</i> Bail.	9.5 $\pm$ 0.7	3 $\pm$ 0.3	2.9 $\pm$ 0.5	15.3 $\pm$ 0.6
7	<i>Cynodon dactylon</i> Pers.	9.6 $\pm$ 0.5	9.5 $\pm$ 0.4	8.5 $\pm$ 0.5	27.6 $\pm$ 0.6
8	<i>Desmodium triflorum</i> (L.) DC.	6.2 $\pm$ 0.8	2.6 $\pm$ 0.2	3.8 $\pm$ 0.4	12.5 $\pm$ 0.8
9	<i>Eleusine indica</i> (L.) Gaertn.	5 $\pm$ 0.6	3.5 $\pm$ 1	5.7 $\pm$ 1.4	14.2 $\pm$ 2.4
10	<i>Euphorbia hirta</i> L.	1.7 $\pm$ 0.4	0.2 $\pm$ 0.1	1.1 $\pm$ 0.2	3 $\pm$ 0.5
11	<i>Hemigraphis hirta</i> T. Anders.	10.7 $\pm$ 0.5	16.2 $\pm$ 0.9	12.8 $\pm$ 0.8	39.7 $\pm$ 1.8
12	<i>Ichnanthus vicinus</i> (Bail) Merr.	2.8 $\pm$ 0.4	1.7 $\pm$ 0.2	5.7 $\pm$ 1.1	10.2 $\pm$ 1
13	<i>Imperata cylindrica</i> (L.) P. Beauv.	3.9 $\pm$ 0.4	2 $\pm$ 0.3	4.3 $\pm$ 0.6	10.3 $\pm$ 0.9
14	<i>Leucas aspera</i> (Willd.) Link.	2.2 $\pm$ 0.3	0.2 $\pm$ 0.05	0.9 $\pm$ 0.1	3.3 $\pm$ 0.4
15	<i>Mimosa pudica</i> L.	0.5 $\pm$ 0.3	0.1 $\pm$ 0.1	0.5 $\pm$ 0.3	1.2 $\pm$ 0.6
16	<i>Ocimum basilicum</i> L.	1.1 $\pm$ 0.4	0.1 $\pm$ 0.05	0.4 $\pm$ 0.2	1.6 $\pm$ 0.6
17	<i>Oplismenus compositus</i> (L.) P. Beauv.	11.3 $\pm$ 0.2	33.3 $\pm$ 1.4	24.7 $\pm$ 1.4	69.3 $\pm$ 2.9
18	<i>Phyllanthus niruri</i> L.	2.2 $\pm$ 0.4	0.4 $\pm$ 0.1	1.6 $\pm$ 0.4	4.2 $\pm$ 0.5
19	<i>Sida cordifolia</i> L.	4.5 $\pm$ 0.5	1.3 $\pm$ 0.2	2.6 $\pm$ 0.6	8.5 $\pm$ 0.7
20	<i>Sporobolus diander</i> (Retz.) P. Beauv.	3.9 $\pm$ 0.4	1.2 $\pm$ 0.1	2.7 $\pm$ 0.2	7.8 $\pm$ 0.4
	Total	100$\pm$ 9.3	100$\pm$ 7	100$\pm$ 10.4	300$\pm$19.7

Table 4.11a: List of Species with their Number, Frequency, Density and Abundance Values in Site-B (*Acacia auriculiformis* A cunn. ex Benth. Plantation Stand) during Winter Season (November- February 2003-2004 & 2004-2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	NIP	Frequency	Density	Abundance
1	<i>Acacia auriculiformis</i> A cunn. ex Benth. (Seedling)	12 $\pm$ 4.1	45 $\pm$ 15.2	1.2 $\pm$ 0.4	1.3 $\pm$ 0.5
2	<i>Alysicarpus vaginalis</i> DC.	16 $\pm$ 1.2	55 $\pm$ 5.6	1.6 $\pm$ 0.1	3.2 $\pm$ 0.4
3	<i>Brachiaria</i> sp	9 $\pm$ 3.4	30 $\pm$ 10.5	0.9 $\pm$ 0.3	1.5 $\pm$ 0.5
4	<i>Centella asiatica</i> (L) Urban.	1.5 $\pm$ 0.7	5 $\pm$ 1.7	0.2 $\pm$ 0.1	1.5 $\pm$ 0.7
5	<i>Cynodon dactylon</i> Pers.	126.5 $\pm$ 20.2	90 $\pm$ 4.7	12.7 $\pm$ 2	13.7 $\pm$ 1.8
6	<i>Cyperus rotundus</i> L.	36.5 $\pm$ 12.4	45 $\pm$ 15.3	3.7 $\pm$ 1.2	4.1 $\pm$ 1.4
7	<i>Desmodium triflorum</i> (L.) DC.	5.5 $\pm$ 1.9	20 $\pm$ 7.1	0.6 $\pm$ 0.2	1.6 $\pm$ 0.7
8	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	4 $\pm$ 1.6	15 $\pm$ 6.4	0.4 $\pm$ 0.2	1.5 $\pm$ 0.5
9	<i>Eleusine indica</i> (L.) Gaertn.	6 $\pm$ 2.1	15 $\pm$ 6	0.6 $\pm$ 0.2	2.6 $\pm$ 1.1
10	<i>Evolvulus nummularius</i> L.	79 $\pm$ 10.6	65 $\pm$ 11.8	7.9 $\pm$ 1.1	14.2 $\pm$ 1.7
11	<i>Hemigraphis hirta</i> T. Anders.	6.5 $\pm$ 1	30 $\pm$ 4.2	0.7 $\pm$ 0.1	3 $\pm$ 1
12	<i>Imperata cylindrica</i> (L.) P. Beauv.	6 $\pm$ 2.4	10 $\pm$ 4.2	0.6 $\pm$ 0.2	4.3 $\pm$ 2.2
13	<i>Leucas aspera</i> (Willd.) Link.	6.5 $\pm$ 2.4	25 $\pm$ 9.9	0.7 $\pm$ 0.2	1.6 $\pm$ 0.6
14	<i>Nelsonia campestris</i> R. Br.	9.5 $\pm$ 1.8	35 $\pm$ 5.8	1 $\pm$ 0.2	3.6 $\pm$ 0.8
15	<i>Oxalis corniculata</i> L.	6 $\pm$ 2.2	25 $\pm$ 9.2	0.6 $\pm$ 0.2	1.3 $\pm$ 0.5
16	<i>Sida cordifolia</i> L.	3.5 $\pm$ 0.8	20 $\pm$ 4.5	0.4 $\pm$ 0.1	1.6 $\pm$ 0.4
17	<i>Sporobolus diander</i> (Retz.) P. Beauv.	4 $\pm$ 0.8	20 $\pm$ 5.2	0.4 $\pm$ 0.1	2.2 $\pm$ 0.4
	Total	338$\pm$ 69.6	550$\pm$ 127.4	33.8$\pm$ 7	62.7$\pm$ 15.2

NIP= Number of individual plants

Table 4.11b: List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-B (*Acacia auriculiformis* A cunn. ex Benth. Plantation Stand) during Winter Season (November-February, 2003-2004, & 2004-2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	Relative frequency	Relative density	Relative abundance	IVI
1	<i>Acacia auriculiformis</i> A cunn. ex Benth. (Seedling)	6.2 $\pm$ 2.1	3.5 $\pm$ 1.2	1.7 $\pm$ 0.6	11.4 $\pm$ 3.9
2	<i>Alysicarpus vaginalis</i> DC.	11.5 $\pm$ 1.8	4.8 $\pm$ 0.4	5.5 $\pm$ 0.7	21.7 $\pm$ 2.1
3	<i>Brachiaria</i> sp	4.1 $\pm$ 1.4	2.6 $\pm$ 0.9	1.8 $\pm$ 0.7	8.5 $\pm$ 2.9
4	<i>Centella asiatica</i> (L) Urban.	0.7 $\pm$ 0.2	0.4 $\pm$ 0.2	1.8 $\pm$ 0.8	2.9 $\pm$ 1.2
5	<i>Cynodon dactylon</i> Pers.	19.4 $\pm$ 3	37.7 $\pm$ 6	26.9 $\pm$ 5.5	84 $\pm$ 14.1
6	<i>Cyperus rotundus</i> L.	6.3 $\pm$ 2.2	10.6 $\pm$ 3.6	5 $\pm$ 1.7	21.9 $\pm$ 7.4
7	<i>Desmodium triflorum</i> (L.) DC.	2.7 $\pm$ 1	1.6 $\pm$ 0.6	2 $\pm$ 0.9	6.3 $\pm$ 2.2
8	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	2 $\pm$ 0.8	1.1 $\pm$ 0.5	1.8 $\pm$ 0.7	4.9 $\pm$ 1.7
9	<i>Eleusine indica</i> (L.) Gaertn.	2.1 $\pm$ 0.9	1.7 $\pm$ 0.6	3.1 $\pm$ 1.3	7 $\pm$ 2.4
10	<i>Evolvulus nummularius</i> L.	15.9 $\pm$ 4	23.6 $\pm$ 3.3	23 $\pm$ 1.5	62.5 $\pm$ 7.9
11	<i>Hemigraphis hirta</i> T. Anders.	5.9 $\pm$ 1	2 $\pm$ 0.3	5.6 $\pm$ 2.1	13.4 $\pm$ 2.3
12	<i>Imperata cylindrica</i> (L.) P. Beauv.	1.4 $\pm$ 0.6	1.7 $\pm$ 0.7	5 $\pm$ 2.4	8.1 $\pm$ 3.3
13	<i>Leucas aspera</i> (Willd.) Link.	3.4 $\pm$ 1.3	1.9 $\pm$ 0.7	1.9 $\pm$ 0.8	7.2 $\pm$ 2.4
14	<i>Nelsonia campestris</i> R. Br.	7.2 $\pm$ 1.5	2.9 $\pm$ 0.6	6.5 $\pm$ 1.9	16.6 $\pm$ 2.6
15	<i>Oxalis corniculata</i> L.	3.4 $\pm$ 1.2	1.8 $\pm$ 0.6	1.7 $\pm$ 0.7	6.8 $\pm$ 2.4
16	<i>Sida cordifolia</i> L.	3.9 $\pm$ 0.8	1 $\pm$ 0.2	3.2 $\pm$ 1	8.1 $\pm$ 1.6
17	<i>Sporobolus diander</i> (Retz.) P. Beauv.	3.9 $\pm$ 1.3	1.2 $\pm$ 0.2	3.5 $\pm$ 0.6	8.6 $\pm$ 1.5
	Total	100$\pm$25.2	100$\pm$20.6	100$\pm$23.8	300$\pm$62

Table 4.12a: List of Species with their Number, Frequency, Density and Abundance Values in **Site-B** (*Acacia auriculiformis* A cunn. ex Benth. Plantation Stand) during **Summer Season** (March- June 2004 & 2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	NIP	Frequency	Density	Abundance
1	<i>Acacia auriculiformis</i> A cunn. ex Benth.(Seedling)	20 $\pm$ 8.2	45 $\pm$ 15.3	2 $\pm$ 0.8	2.2 $\pm$ 0.8
2	<i>Azadirachta indica</i> A. Juss. (Seedling)	1 $\pm$ 0.5	5 $\pm$ 2.7	0.1 $\pm$ 0.1	0.7 $\pm$ 0.4
3	<i>Centella asiatica</i> (L) Urban.	1.5 $\pm$ 0.6	5 $\pm$ 1.7	0.2 $\pm$ 0.1	1.5 $\pm$ 0.6
4	<i>Clerodendrum viscosum</i> Vent.	0.5 $\pm$ 0.3	5 $\pm$ 3.1	0.1 $\pm$ 0	0.3 $\pm$ 0.2
5	<i>Croton bonplandianum</i> Bail.	23 $\pm$ 7.8	45 $\pm$ 15.4	2.3 $\pm$ 0.8	2.7 $\pm$ 0.9
6	<i>Cynodon dactylon</i> Pers.	109 $\pm$ 19.9	65 $\pm$ 10	10.9 $\pm$ 2	16.4 $\pm$ 2
7	<i>Cyperus rotundus</i> L.	187 $\pm$ 57	60 $\pm$ 11.3	18.7 $\pm$ 5.7	24.6 $\pm$ 5
8	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	3.5 $\pm$ 1.6	5 $\pm$ 1.7	0.4 $\pm$ 0.2	3.5 $\pm$ 1.6
9	<i>Eleusine indica</i> (L.) Gaertn.	187.5 $\pm$ 59	90 $\pm$ 6	18.8 $\pm$ 5.9	18.9 $\pm$ 5.8
10	<i>Euphorbia hirta</i> L.	0.5 $\pm$ 0.3	5 $\pm$ 2.7	0.1 $\pm$ 0	0.3 $\pm$ 0.2
11	<i>Evolvulus nummularius</i> L.	194 $\pm$ 39.3	80 $\pm$ 7.3	19.4 $\pm$ 3.9	22.3 $\pm$ 3.1
12	<i>Hemigraphis hirta</i> T. Anders.	11.5 $\pm$ 3.8	20 $\pm$ 4.9	1.2 $\pm$ 0.4	4.5 $\pm$ 1.6
13	<i>Imperata cylindrica</i> (L.) P. Beauv.	20.5 $\pm$ 7.1	15 $\pm$ 6	2.1 $\pm$ 0.7	8.7 $\pm$ 3.5
14	<i>Isachne miliacea</i> Roth.	1105 $\pm$ 315.9	90 $\pm$ 5.6	110.5 $\pm$ 31.6	113 $\pm$ 30.8
15	<i>Leucas aspera</i> (Willd.) Link.	3 $\pm$ 1.3	20 $\pm$ 8.2	0.3 $\pm$ 0.1	0.7 $\pm$ 0.3
16	<i>Nelsonia campestris</i> R. Br.	4.5 $\pm$ 1.4	30 $\pm$ 7.3	0.5 $\pm$ 0.1	1.2 $\pm$ 0.2
17	<i>Saccharum spontaneum</i> L.	3 $\pm$ 1.7	10 $\pm$ 5.2	0.3 $\pm$ 0.2	0.9 $\pm$ 0.5
18	<i>Sporobolus diander</i> (Retz.) P. Beauv.	43 $\pm$ 16.1	45 $\pm$ 15.7	4.3 $\pm$ 1.6	4.7 $\pm$ 1.6
19	<i>Vitis trifolia</i> (L.) Don	0.5 $\pm$ 0.3	5 $\pm$ 3.4	0.1 $\pm$ 0	0.2 $\pm$ 0.1
	Total	1918.5 $\pm$ 542.3	645 $\pm$ 133.4	191.9 $\pm$ 54.2	227.3 $\pm$ 59.4

NIP= Number of individual plants

Table 4.12b: List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in **Site-B** (*Acacia auriculiformis* A cunn. ex Benth. Plantation Stand) during Summer Season (March- June 2004 & 2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	Relative frequency	Relative density	Relative abundance	IVI
1	<i>Acacia auriculiformis</i> A cunn. ex Benth.(Seedling)	5.6 $\pm$ 1.9	0.8 $\pm$ 0.4	0.7 $\pm$ 0.3	7.2 $\pm$ 2.4
2	<i>Azadirachta indica</i> A. Juss. (Seedling)	0.6 $\pm$ 0.3	0 $\pm$ 0	0.2 $\pm$ 0.1	0.9 $\pm$ 0.4
3	<i>Centella asiatica</i> (L) Urban.	0.6 $\pm$ 0.2	0.1 $\pm$ 0	0.5 $\pm$ 0.2	1.2 $\pm$ 0.4
4	<i>Clerodendrum viscosum</i> Vent.	0.6 $\pm$ 0.3	0 $\pm$ 0	0.1 $\pm$ 0.1	0.7 $\pm$ 0.4
5	<i>Croton bonplandianum</i> Bail.	5.7 $\pm$ 2	1 $\pm$ 0.3	0.9 $\pm$ 0.3	7.5 $\pm$ 2.5
6	<i>Cynodon dactylon</i> Pers.	11.6 $\pm$ 2.3	6.8 $\pm$ 1.6	8 $\pm$ 1.1	26.4 $\pm$ 4.9
7	<i>Cyperus rotundus</i> L.	11.1 $\pm$ 2.6	13.4 $\pm$ 4.4	14.9 $\pm$ 3.9	39.4 $\pm$ 10.8
8	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	0.6 $\pm$ 0.2	0.1 $\pm$ 0.1	1.1 $\pm$ 0.5	1.9 $\pm$ 0.8
9	<i>Eleusine indica</i> (L.) Gaertn.	15.2 $\pm$ 1.9	13.5 $\pm$ 4.3	12.5 $\pm$ 4	41.2 $\pm$ 10.1
10	<i>Euphorbia hirta</i> L.	0.6 $\pm$ 0.3	0 $\pm$ 0	0.1 $\pm$ 0.1	0.7 $\pm$ 0.4
11	<i>Evolvulus nummularius</i> L.	14 $\pm$ 2.2	13 $\pm$ 3.3	12.7 $\pm$ 2.8	39.6 $\pm$ 8.2
12	<i>Hemigraphis hirta</i> T. Anders.	3 $\pm$ 0.8	0.5 $\pm$ 0.2	1.7 $\pm$ 0.6	5.1 $\pm$ 1.1
13	<i>Imperata cylindrica</i> (L.) P. Beauv.	1.9 $\pm$ 0.8	0.9 $\pm$ 0.3	2.9 $\pm$ 1.2	5.6 $\pm$ 1.9
14	<i>Isachne miliacea</i> Roth.	14.4 $\pm$ 1.1	47.6 $\pm$ 11.2	40.9 $\pm$ 8.3	103 $\pm$ 18.9
15	<i>Leucas aspera</i> (Willd.) Link.	2.4 $\pm$ 1	0.1 $\pm$ 0.1	0.2 $\pm$ 0.1	2.8 $\pm$ 1.1
16	<i>Nelsonia campestris</i> R. Br.	4.5 $\pm$ 0.9	0.2 $\pm$ 0.1	0.6 $\pm$ 0.1	5.3 $\pm$ 1
17	<i>Saccharum spontaneum</i> L.	1.2 $\pm$ 0.6	0.1 $\pm$ 0.1	0.3 $\pm$ 0.2	1.7 $\pm$ 0.9
18	<i>Sporobolus diander</i> (Retz.) P. Beauv.	5.7 $\pm$ 2	1.8 $\pm$ 0.7	1.5 $\pm$ 0.5	9 $\pm$ 3.2
19	<i>Vitis trifolia</i> (L.) Don	0.6 $\pm$ 0.4	0 $\pm$ 0	0.1 $\pm$ 0	0.7 $\pm$ 0.5
	Total	100$\pm$21.7	100$\pm$27	100$\pm$24.4	300$\pm$70

Table 4.13a: List of Species with their Number, Frequency, Density and Abundance Values in Site-C (Native-mixed Plantation Stand) during Rainy Season (July- October 2003 & 2004)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	NIP	Frequency	Density	Abundance
1	<i>Amaranthus spinosus</i> L.	3 $\pm$ 1.3	25 $\pm$ 11.4	0.3 $\pm$ 0.1	0.5 $\pm$ 0.2
2	<i>Amaranthus viridis</i> L.	7 $\pm$ 2.4	20 $\pm$ 7.1	0.7 $\pm$ 0.2	2 $\pm$ 0.7
3	<i>Azadirachta indica</i> A. Juss. (Seedling)	6 $\pm$ 0.9	30 $\pm$ 4.7	0.6 $\pm$ 0.1	2.3 $\pm$ 0.3
4	<i>Brachiaria distachya</i> (L.) Stapf.	59 $\pm$ 21.5	30 $\pm$ 10.2	5.9 $\pm$ 2.2	9.6 $\pm$ 3.3
5	<i>Brachiaria</i> sp	50 $\pm$ 21.2	35 $\pm$ 11.9	5 $\pm$ 2.1	7 $\pm$ 2.8
6	<i>Calotropis procera</i> Br.	2.5 $\pm$ 1	10 $\pm$ 4.9	0.3 $\pm$ 0.1	1.8 $\pm$ 0.8
7	<i>Cassia sophera</i> L.	1.5 $\pm$ 0.6	5 $\pm$ 1.7	0.2 $\pm$ 0.1	1.5 $\pm$ 0.6
8	<i>Clerodendrum viscosum</i> Vent.	8 $\pm$ 1.4	45 $\pm$ 5	0.8 $\pm$ 0.1	1.7 $\pm$ 0.2
9	<i>Croton bonplandianum</i> Bail.	7 $\pm$ 2.3	25 $\pm$ 4.5	0.7 $\pm$ 0.2	2.4 $\pm$ 0.5
10	<i>Cyperus kyllinga</i> Endl.	62.5 $\pm$ 6.1	45 $\pm$ 5	6.3 $\pm$ 0.6	14.5 $\pm$ 1.4
11	<i>Desmodium triflorum</i> (L.) DC.	134.5 $\pm$ 10.5	90 $\pm$ 3.7	13.5 $\pm$ 1.1	15.1 $\pm$ 1.1
12	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	67 $\pm$ 7.6	40 $\pm$ 3.3	6.7 $\pm$ 0.8	17.6 $\pm$ 2.1
13	<i>Echinochloa colonum</i> (L.) Link.	88.5 $\pm$ 4.1	65 $\pm$ 5.4	8.9 $\pm$ 0.4	14 $\pm$ 0.7
14	<i>Eleusine indica</i> (L.) Gaertn.	300 $\pm$ 23	100 $\pm$ 0	30 $\pm$ 2.3	30 $\pm$ 2.3
15	<i>Evolvulus nummularius</i> L.	251.5 $\pm$ 9.7	100 $\pm$ 0	25.2 $\pm$ 1	25.2 $\pm$ 1
16	<i>Glycosmis pentaphylla</i> (Retz.) A. DC.	2.5 $\pm$ 1	15 $\pm$ 6.7	0.3 $\pm$ 0.1	1 $\pm$ 0.4
17	<i>Ichnanthus vicinus</i> (Bail) Merr.	93.5 $\pm$ 5.8	80 $\pm$ 6.1	9.4 $\pm$ 0.6	12.2 $\pm$ 1
18	<i>Leucas aspera</i> (Willd.) Link.	15 $\pm$ 3.9	30 $\pm$ 4.9	1.5 $\pm$ 0.4	4.8 $\pm$ 1.2
19	<i>Lippia nodiflora</i> (L.) Rich.	9 $\pm$ 2.9	15 $\pm$ 3.7	0.9 $\pm$ 0.3	5.5 $\pm$ 2
20	<i>Ocimum basilicum</i> L.	20.5 $\pm$ 3.8	30 $\pm$ 5.2	2.1 $\pm$ 0.4	9.4 $\pm$ 2.7
21	<i>Oplismenus compositus</i> (L.) P. Beauv.	122 $\pm$ 7	70 $\pm$ 6.8	12.2 $\pm$ 0.7	18.3 $\pm$ 1.2
22	<i>Oxalis corniculata</i> L.	17 $\pm$ 6.2	25 $\pm$ 9.3	1.7 $\pm$ 0.6	4.1 $\pm$ 1.8
23	<i>Phoenix sylvestris</i> (L.) Roxb. (Seedling)	2 $\pm$ 0.6	20 $\pm$ 5.6	0.2 $\pm$ 0.1	0.9 $\pm$ 0.1
24	<i>Psidium guajava</i> (L.) Bat. (Seedling)	4 $\pm$ 0.6	10 $\pm$ 1.5	0.4 $\pm$ 0.1	3.8 $\pm$ 0.7
25	<i>Sida cordifolia</i> L.	47 $\pm$ 4.5	55 $\pm$ 5	4.7 $\pm$ 0.4	9.5 $\pm$ 1.6
26	<i>Syzygium cumini</i> Skeel. (seedling)	1 $\pm$ 0.4	10 $\pm$ 3.7	0.1 $\pm$ 0.04	0.6 $\pm$ 0.2
27	<i>Temindia ajuna</i> (Roxb.) Wt. & Arn (Seedling)	3 $\pm$ 0.3	25 $\pm$ 3.4	0.3 $\pm$ 0.03	1.3 $\pm$ 0.1
28	<i>Zizyphus mauritiana</i> Lamk. (Seedling)	1 $\pm$ 0.4	10 $\pm$ 4.2	0.1 $\pm$ 0.04	0.4 $\pm$ 0.2
	Total	1385.5$\pm$151.1	1060$\pm$145.1	138.6$\pm$15.1	217$\pm$31.1

NIP= Number of individual plants

Table 4.13b: List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-C (Native-mixed Plantation Stand) during Rainy Season (July- October 2003 & 2004)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	Relative frequency	Relative density	Relative abundance	IVI
1	<i>Amaranthus spinosus</i> L.	1.9 $\pm$.9	0.2 $\pm$ 0.1	0.2 $\pm$ 0.1	2.3 $\pm$ 1
2	<i>Amaranthus viridis</i> L.	1.6 $\pm$ 0.6	0.4 $\pm$ 0.2	0.8 $\pm$ 0.3	2.8 $\pm$ 0.9
3	<i>Azadirachta indica</i> A. Juss. (Seedling)	2.9 $\pm$ 0.5	0.4 $\pm$ 0.1	1.1 $\pm$ 0.1	4.4 $\pm$ 0.4
4	<i>Brachiaria distachya</i> (L.) Stapf.	2.4 $\pm$ 0.8	3.7 $\pm$ 1.3	3.9 $\pm$ 1.3	9.9 $\pm$ 3.5
5	<i>Brachiaria</i> sp	2.8 $\pm$ 1	3.1 $\pm$ 1.3	2.8 $\pm$ 1.1	8.7 $\pm$ 3.2
6	<i>Calotropis procera</i> Br.	0.8 $\pm$ 0.4	0.2 $\pm$ 0.1	0.7 $\pm$ 0.3	1.6 $\pm$ 0.6
7	<i>Cassia sophera</i> L.	0.4 $\pm$ 0.1	0.1 $\pm$ 0.04	0.6 $\pm$ 0.2	1.1 $\pm$ 0.4
8	<i>Clerodendrum viscosum</i> Vent.	4.5 $\pm$ 0.7	0.6 $\pm$ 0.1	0.8 $\pm$ 0.1	6 $\pm$ 0.9
9	<i>Croton bonplandianum</i> Bail.	2.3 $\pm$ 0.4	0.5 $\pm$ 0.1	1 $\pm$ 0.2	3.8 $\pm$ 0.6
10	<i>Cyperus kyllinga</i> Endl.	4.5 $\pm$ 0.7	4.7 $\pm$ 0.6	6.9 $\pm$ 0.9	16.1 $\pm$ 1.6
11	<i>Desmodium triflorum</i> (L.) DC.	8.8 $\pm$ 0.7	10 $\pm$ 1	7.1 $\pm$ 0.7	26 $\pm$ 2
12	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	3.9 $\pm$ 0.5	5.2 $\pm$ 0.8	8.6 $\pm$ 1.3	17.7 $\pm$ 2.2
13	<i>Echinochloa colonum</i> (L.) Link.	6.4 $\pm$ 0.7	6.6 $\pm$ 0.6	6.6 $\pm$ 0.4	19.6 $\pm$ 1.4
14	<i>Eleusine indica</i> (L.) Gaertn.	9.8 $\pm$ 0.6	21.5 $\pm$ 0.9	13.8 $\pm$ 0.7	45.1 $\pm$ 1.5
15	<i>Evolvulus nummularius</i> L.	9.8 $\pm$ 0.6	18.4 $\pm$ 0.9	11.7 $\pm$ 0.5	40 $\pm$ 1.9
16	<i>Glycosmis pentaphylla</i> (Retz.) A. DC.	1.2 $\pm$ 0.5	0.2 $\pm$ 0.1	0.4 $\pm$ 0.1	1.7 $\pm$ 0.7
17	<i>Ichnanthus vicinus</i> (Bail) Merr.	7.6 $\pm$ 0.5	6.8 $\pm$ 0.3	5.7 $\pm$ 0.6	20.1 $\pm$ 0.8
18	<i>Leucas aspera</i> (Willd.) Link.	2.7 $\pm$ 0.3	1 $\pm$ 0.2	2.1 $\pm$ 0.4	5.8 $\pm$ 0.7
19	<i>Lippia nodiflora</i> (L.) Rich.	1.4 $\pm$ 0.3	0.6 $\pm$ 0.2	2.2 $\pm$ 0.8	4.2 $\pm$ 1
20	<i>Ocimum basilicum</i> L.	3 $\pm$ 0.6	1.6 $\pm$ 0.4	4.7 $\pm$ 1.4	9.3 $\pm$ 1.6
21	<i>Oplismenus compositus</i> (L.) P. Beauv.	6.7 $\pm$ 0.6	8.9 $\pm$ 0.5	8.7 $\pm$ 0.8	24.3 $\pm$ 1.2
22	<i>Oxalis corniculata</i> L.	2 $\pm$ 0.8	1.1 $\pm$ 0.4	1.7 $\pm$ 0.8	4.8 $\pm$ 1.7
23	<i>Phoenix sylvestris</i> (L.) Roxb. (Seedling)	1.9 $\pm$ 0.5	0.1 $\pm$ 0.04	0.4 $\pm$ 0.1	2.5 $\pm$ 0.6
24	<i>Psidium guajava</i> (L.) Bat. (Seedling)	1 $\pm$ 0.2	0.3 $\pm$ 0.1	1.8 $\pm$ 0.3	3.1 $\pm$ 0.5
25	<i>Sida cordifolia</i> L.	5.2 $\pm$ 0.4	3.4 $\pm$ 0.4	4.5 $\pm$ 0.8	13.1 $\pm$ 1
26	<i>Syzygium cumini</i> Skeel. (seedling)	1 $\pm$ 0.4	0.1 $\pm$ 0.03	0.3 $\pm$ 0.1	1.3 $\pm$ 0.5
27	<i>Terminalia arjuna</i> (Roxb.) Wt. & Arn (Seedling)	2.5 $\pm$ 0.4	0.2 $\pm$ 0.03	0.6 $\pm$ 0	3.3 $\pm$ 0.4
28	<i>Zizyphus mauritiana</i> Lamk. (Seedling)	1 $\pm$ 0.4	0.1 $\pm$ 0.03	0.2 $\pm$ 0.1	1.2 $\pm$ 0.5
	Total	100$\pm$ 15	100$\pm$ 10.6	100$\pm$ 14.7	300$\pm$ 33.4

Table 4.14a: List of Species with their Number, Frequency, Density and Abundance Values in Site-C (Native-mixed Plantation Stand) during Winter Season (November- February 2003-2004 & 2004-2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	NIP	Frequency	Density	Abundance
1	<i>Achyranthes aspera</i> L.	39.5 $\pm$ 4.7	50 $\pm$ 6	4 $\pm$ 0.5	8.3 $\pm$ 0.9
2	<i>Azadirachta indica</i> A. Juss. (Seedling)	2.5 $\pm$ 0.5	20 $\pm$ 3.7	0.3 $\pm$ 0.1	1.3 $\pm$ 0.2
3	<i>Calotropis procera</i> Br.	2.5 $\pm$ 1	20 $\pm$ 7.1	0.3 $\pm$ 0.1	0.6 $\pm$ 0.2
4	<i>Clerodendrum viscosum</i> Vent.	4 $\pm$ 0.9	35 $\pm$ 5.2	0.4 $\pm$ 0.1	1.1 $\pm$ 0.1
5	<i>Croton bonplandianum</i> Bail.	1 $\pm$ 0.5	5 $\pm$ 1.7	0.1 $\pm$ 0	1 $\pm$ 0.5
6	<i>Cyperus rotundus</i> L.	48 $\pm$ 17.2	20 $\pm$ 7.5	4.8 $\pm$ 1.7	12.5 $\pm$ 4.3
7	<i>Desmodium triflorum</i> (L.) DC.	7 $\pm$ 2.6	5 $\pm$ 1.7	0.7 $\pm$ 0.3	7 $\pm$ 2.6
8	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	11.5 $\pm$ 4.6	10 $\pm$ 3.7	1.2 $\pm$ 0.5	5.8 $\pm$ 2.2
9	<i>Digitaria sanguinalis</i> (L.) Scop.	12.5 $\pm$ 4.5	25 $\pm$ 9	1.3 $\pm$ 0.4	2.6 $\pm$ 0.9
10	<i>Eleusine indica</i> (L.) Gaertn.	301.5 $\pm$ 29.2	100 $\pm$ 0	30.2 $\pm$ 2.9	30.2 $\pm$ 2.9
11	<i>Evolvulus nummularius</i> L.	138 $\pm$ 19.6	100 $\pm$ 0	13.8 $\pm$ 2	13.8 $\pm$ 2
12	<i>Nelsonia campestris</i> R. Br.	61 $\pm$ 10.2	50 $\pm$ 8.2	6.1 $\pm$ 1	12.7 $\pm$ 1.4
13	<i>Oplismenus compositus</i> (L.) P. Beauv.	23 $\pm$ 8.3	15 $\pm$ 5.6	2.3 $\pm$ 0.8	8 $\pm$ 2.8
14	<i>Phoenix sylvestris</i> (L.) Roxb. (Seedling)	2 $\pm$ 0.8	20 $\pm$ 7.6	0.2 $\pm$ 0.1	0.6 $\pm$ 0.2
15	<i>Psidium guajava</i> (L.) Bat. (Seedling)	2 $\pm$ 0.6	10 $\pm$ 1.5	0.2 $\pm$ 0.1	1.9 $\pm$ 0.6
16	<i>Solanum nigrum</i> L.	3 $\pm$ 1.2	15 $\pm$ 6	0.3 $\pm$ 0.1	1.3 $\pm$ 0.6
17	<i>Sporobolus diander</i> (Retz.) P. Beauv.	25.5 $\pm$ 1.4	25 $\pm$ 2.7	2.6 $\pm$ 0.1	11.2 $\pm$ 1.2
18	<i>Terminalia arjuna</i> (Roxb.) Wt. & Arn (Seedling)	1 $\pm$ 0.3	10 $\pm$ 3	0.1 $\pm$ 0.03	0.7 $\pm$ 0.2
19	<i>Zizyphus mauritiana</i> Lamk. (Seedling)	0.5 $\pm$ 0.4	5 $\pm$ 4	0.1 $\pm$ 0.04	0.2 $\pm$ 0.1
	Total	686$\pm$ 108.5	540$\pm$ 84	68.6$\pm$ 10.8	120.7$\pm$ 23.9

NIP= Number of individual plants

Table 4.14b: List of Species with their Relative Frequency, Relative Density, Relative Abundance and Importance Value Index (IVI) in Site-C (Native-mixed Plantation Stand) during Winter Season (November- February 2003-2004 & 2004-2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	Relative frequency	Relative density	Relative abundance	IVI
1	<i>Achyranthes aspera</i> L.	9.3 $\pm$ 1	5.9 $\pm$ 0.7	8.1 $\pm$ 1.8	23.2 $\pm$ 2.2
2	<i>Azadirachta indica</i> A. Juss. (Seedling)	3.9 $\pm$ 0.8	0.4 $\pm$ 0.1	1.3 $\pm$ 0.3	5.6 $\pm$ 0.9
3	<i>Calotropis procera</i> Br.	3.2 $\pm$ 1.1	0.3 $\pm$ 0.1	0.4 $\pm$ 0.1	3.8 $\pm$ 1.4
4	<i>Clerodendrum viscosum</i> Vent.	6.8 $\pm$ 1.1	0.7 $\pm$ 0.2	1.1 $\pm$ 0.2	8.6 $\pm$ 1.4
5	<i>Croton bonplandianum</i> Bail.	0.8 $\pm$ 0.3	0.1 $\pm$ 0.1	0.6 $\pm$ 0.3	1.5 $\pm$ 0.6
6	<i>Cyperus rotundus</i> L.	3.2 $\pm$ 1.2	6.1 $\pm$ 2.23	7.8 $\pm$ 2.6	17.1 $\pm$ 5.8
7	<i>Desmodium triflorum</i> (L.) DC.	0.8 $\pm$ 0.3	0.9 $\pm$ 0.3	4.4 $\pm$ 1.7	6.1 $\pm$ 2.3
8	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	1.6 $\pm$ 0.6	1.4 $\pm$ 0.6	3.5 $\pm$ 1.3	6.6 $\pm$ 2.4
9	<i>Digitaria sanguinalis</i> (L.) Scop.	4 $\pm$ 1.4	1.6 $\pm$ 0.6	1.6 $\pm$ 0.6	7.2 $\pm$ 2.5
10	<i>Eleusine indica</i> (L.) Gaertn.	19.1 $\pm$ 1.1	43 $\pm$ 2.3	25.7 $\pm$ 1.8	87.8 $\pm$ 3.6
11	<i>Evolvulus nummularius</i> L.	19.1 $\pm$ 1.1	21.8 $\pm$ 3.8	14.5 $\pm$ 3.1	55.4 $\pm$ 7.9
12	<i>Nelsonia campestris</i> R. Br.	10.1 $\pm$ 2	9.7 $\pm$ 1.9	11.7 $\pm$ 1.6	31.6 $\pm$ 5.1
13	<i>Oplismenus compositus</i> (L.) P. Beauv.	2.4 $\pm$ 0.9	2.9 $\pm$ 1	5 $\pm$ 1.8	10.2 $\pm$ 3.5
14	<i>Phoenix sylvestris</i> (L.) Roxb. (Seedling)	4 $\pm$ 1.6	0.3 $\pm$ 0.1	0.7 $\pm$ 0.2	5 $\pm$ 1.9
15	<i>Psidium guajava</i> (L.) Bat. (Seedling)	1.9 $\pm$ 0.3	0.3 $\pm$ 0.1	2 $\pm$ 0.7	4.2 $\pm$ 0.9
16	<i>Solanum nigrum</i> L.	2.4 $\pm$ 0.9	0.4 $\pm$ 0.2	0.8 $\pm$ 0.4	3.6 $\pm$ 1.2
17	<i>Sporobolus diander</i> (Retz.) P. Beauv.	4.9 $\pm$ 0.7	3.9 $\pm$ 0.4	9.9 $\pm$ 1	18.7 $\pm$ 1.8
18	<i>Terminalia arjuna</i> (Roxb.) Wt. & Arn (Seedling)	1.9 $\pm$ 0.5	0.2 $\pm$ 0.04	0.8 $\pm$ 0.2	2.8 $\pm$ 0.6
19	<i>Zizyphus mauritiana</i> Lamk. (Seedling)	0.8 $\pm$ 0.6	0.1 $\pm$ 0.05	0.1 $\pm$ 0.1	1 $\pm$ 0.8
	Total	100$\pm$ 17.4	100$\pm$ 14.8	100$\pm$ 19.8	300$\pm$ 46.9

Table 4.15a: List of Species with their Number, Frequency, Density and Abundance Values in Site-C (Native-mixed Plantation Stand) during Summer Season (March- June 2004 & 2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	NIP	Frequency	Density	Abundance
1	<i>Azadirachta indica</i> A. Juss. (Seedling)	2 $\pm$ 0.6	20 $\pm$ 6.3	0.2 $\pm$ 0.1	0.7 $\pm$ 0.2
2	<i>Brachiaria</i> sp	84.5 $\pm$ 28.5	40 $\pm$ 13.7	8.5 $\pm$ 2.8	11.1 $\pm$ 3.9
3	<i>Calotropis procera</i> Br.	1 $\pm$ 0.6	10 $\pm$ 5.6	0.1 $\pm$ 0.1	0.3 $\pm$ 0.2
4	<i>Cassia sophera</i> L.	1 $\pm$ 0.4	5 $\pm$ 1.7	0.1 $\pm$ 0	1 $\pm$ 0.4
5	<i>Clerodendrum viscosum</i> Vent.	8.5 $\pm$ 1.3	40 $\pm$ 3.7	0.9 $\pm$ 0.1	2.2 $\pm$ 0.3
6	<i>Cynodon dactylon</i> Pers.	46 $\pm$ 15.5	15 $\pm$ 6.2	4.6 $\pm$ 1.5	18.7 $\pm$ 7.1
7	<i>Cyperus rotundus</i> L.	51 $\pm$ 17.3	50 $\pm$ 16.7	5.1 $\pm$ 1.7	5.1 $\pm$ 1.7
8	<i>Desmodium triflorum</i> (L.) DC.	15.5 $\pm$ 1.9	20 $\pm$ 3.3	1.6 $\pm$ 0.2	8.7 $\pm$ 0.9
9	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	37 $\pm$ 4.7	55 $\pm$ 5.4	3.7 $\pm$ 0.5	7.9 $\pm$ 1.6
10	<i>Digitaria granularis</i> (Trin.) Henr.	8 $\pm$ 2.7	20 $\pm$ 7.7	0.8 $\pm$ 0.3	2.4 $\pm$ 0.9
11	<i>Eleusine compressa</i> (Forssk.) Asch. & Schwiinf.	31.5 $\pm$ 10.6	20 $\pm$ 8.3	3.2 $\pm$ 1.1	10.4 $\pm$ 4.2
12	<i>Eleusine indica</i> (L.) Gaertn.	164.5 $\pm$ 19.8	95 $\pm$ 3.1	16.5 $\pm$ 2	17.1 $\pm$ 1.8
13	<i>Eragrostis tenella</i> (L.) P. Baeuv.	35.5 $\pm$ 11.9	30 $\pm$ 10.7	3.6 $\pm$ 1.2	6.4 $\pm$ 2.3
14	<i>Evolvulus nummularius</i> L.	181.5 $\pm$ 6.7	100 $\pm$ 0	18.2 $\pm$ 0.7	18.2 $\pm$ 0.7
15	<i>Flacourtia indica</i> (Brum. f.) Merr.	0.5 $\pm$ 0.4	5 $\pm$ 4	0.1 $\pm$ 0.04	0.2 $\pm$ 0.1
16	<i>Lantana camara</i> L. Var.	3.5 $\pm$ 1.3	20 $\pm$ 8.2	0.4 $\pm$ 0.1	1.3 $\pm$ 0.7
17	<i>Nelsonia campestris</i> R. Br.	22.5 $\pm$ 9.3	25 $\pm$ 9.6	2.3 $\pm$ 0.9	6.5 $\pm$ 3.5
18	<i>Oplismenus compositus</i> (L.) P. Beauv.	70 $\pm$ 23.6	40 $\pm$ 14.4	7 $\pm$ 2.36	9.5 $\pm$ 3.5
19	<i>Paspalidium flavidum</i> (Retz.) A. Camus	48.5 $\pm$ 16.5	30 $\pm$ 10.7	4.9 $\pm$ 1.65	8.5 $\pm$ 3
20	<i>Phoenix sylvestris</i> (L.) Roxb. (Seedling)	2 $\pm$ 0.4	20 $\pm$ 3.7	0.2 $\pm$ 0.04	1 $\pm$ 0
21	<i>Psidium guajava</i> (L.) Bat. (Seedling)	3 $\pm$ 0.6	15 $\pm$ 3.4	0.3 $\pm$ 0.1	2 $\pm$ 0.3
22	<i>Sida acuta</i> Burm.	9 $\pm$ 3.7	10 $\pm$ 4.5	0.9 $\pm$ 0.4	4.9 $\pm$ 1.7
23	<i>Sida cordifolia</i> L.	11 $\pm$ 3.9	10 $\pm$ 4.2	1.1 $\pm$ 0.4	6.4 $\pm$ 2.3
	Total	837.5$\pm$ 182.2	695$\pm$ 155.1	83.8$\pm$ 18.2	150.3$\pm$ 41.1

NIP= Number of individual plants

Table.15b: List of Species with their Relative Frequency, Relative Density, Relative Abundance and IVI in Site-C (Native-mixed Plantation Stand) during Summer Season (March- June 2004, 2005)

(Data are means of 10 replications $\pm$ S.E)

Sl. no.	Species recorded	Relative frequency	Relative density	Relative abundance	IVI
1	<i>Azadirachta indica</i> A. Juss. (Seedling)	4.2 $\pm$ 1.6	0.3 $\pm$ 0.1	0.7 $\pm$ 0.2	5.3 $\pm$ 1.9
2	<i>Brachiaria</i> sp	4 $\pm$ 1.4	7.2 $\pm$ 2.4	4.8 $\pm$ 1.7	15.9 $\pm$ 5.3
3	<i>Calotropis procera</i> Br.	1 $\pm$ 0.6	0.1 $\pm$ 0.05	0.1 $\pm$ 0.1	1.2 $\pm$ 0.7
4	<i>Cassia sophera</i> L.	0.5 $\pm$ 0.2	0.1 $\pm$ 0.03	0.4 $\pm$ 0.2	1 $\pm$ 0.3
5	<i>Clerodendrum viscosum</i> Vent.	7.2 $\pm$ 1.3	1.1 $\pm$ 0.2	1.9 $\pm$ 0.3	10.2 $\pm$ 1.7
6	<i>Cynodon dactylon</i> Pers.	1.5 $\pm$ 0.6	3.9 $\pm$ 1.31	8 $\pm$ 3	13.4 $\pm$ 4.6
7	<i>Cyperus rotundus</i> L.	5 $\pm$ 1.7	4.3 $\pm$ 1.5	2.2 $\pm$ 0.7	11.5 $\pm$ 3.8
8	<i>Desmodium triflorum</i> (L.) DC.	3.6 $\pm$ 0.8	2.2 $\pm$ 0.4	8.2 $\pm$ 1.9	14 $\pm$ 2.5
9	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	9.5 $\pm$ 1.5	6 $\pm$ 1.4	9.1 $\pm$ 2.6	24.6 $\pm$ 4.9
10	<i>Digitaria granularis</i> (Trin.) Henr.	2 $\pm$ 0.8	0.7 $\pm$ 0.2	1 $\pm$ 0.4	3.7 $\pm$ 1.3
11	<i>Eleusine compressa</i> (Forssk.) Asch. & Schwiinf.	2 $\pm$ 0.8	2.7 $\pm$ 0.9	4.3 $\pm$ 1.7	9 $\pm$ 3
12	<i>Eleusine indica</i> (L.) Gaertn.	17.8 $\pm$ 3.1	26.8 $\pm$ 6	19.1 $\pm$ 4.7	63.7 $\pm$ 13.7
13	<i>Eragrostis tenella</i> (L.) P. Baeuv.	3 $\pm$ 1.1	3 $\pm$ 1	2.8 $\pm$ 1	8.8 $\pm$ 2.9
14	<i>Evolvulus nummularius</i> L.	18.3 $\pm$ 2.9	26.7 $\pm$ 4.2	18.2 $\pm$ 3.8	63.2 $\pm$ 10.7
15	<i>Flacourtia indica</i> (Brum. f.) Merr.	0.5 $\pm$ 0.4	0.04 $\pm$ 0.03	0.1 $\pm$ 0.1	0.6 $\pm$ 0.5
16	<i>Lantana camara</i> L. Var.	2 $\pm$ 0.8	0.3 $\pm$ 0.1	0.5 $\pm$ 0.3	2.8 $\pm$ 1
17	<i>Nelsonia campestris</i> R. Br.	2.5 $\pm$ 0.9	1.9 $\pm$ 0.8	2.8 $\pm$ 1.5	7.2 $\pm$ 2.7
18	<i>Oplismenus compositus</i> (L.) P. Beauv.	4 $\pm$ 1.4	5.9 $\pm$ 1.99	4.2 $\pm$ 1.6	14.1 $\pm$ 4.7
19	<i>Paspalidium flavidum</i> (Retz.) A. Camus	3 $\pm$ 1	4.1 $\pm$ 1.41	3.7 $\pm$ 1.3	10.8 $\pm$ 3.6
20	<i>Phoenix sylvestris</i> (L.) Roxb. (Seedling)	3.7 $\pm$ 0.9	0.3 $\pm$ 0.1	1 $\pm$ 0.2	4.9 $\pm$ 1.1
21	<i>Psidium guajava</i> (L.) Bat. (Seedling)	3.1 $\pm$ 1	0.5 $\pm$ 0.1	2.1 $\pm$ 0.5	5.7 $\pm$ 1.4
22	<i>Sida acuta</i> Burm.	1 $\pm$ 0.4	0.8 $\pm$ 0.32	2.1 $\pm$ 0.7	3.8 $\pm$ 1.3
23	<i>Sida cordifolia</i> L.	1 $\pm$ 0.4	0.9 $\pm$ 0.3	2.8 $\pm$ 1	4.7 $\pm$ 1.6
	Total	100$\pm$ 25.5	100$\pm$ 24.8	100$\pm$ 29.4	300$\pm$ 75.2

Chapter Five

Socio-Economic & Management Aspects of Social Forestry

CHAPTER V

SOCIO-ECONOMIC IMPACTS AND MANAGEMENT ASPECTS OF SOCIAL FORESTRY

5.1 Introduction

The relationship between poverty and environment is one of the basic topics of modern environmental studies. The linkage between poverty and environment has forged a common ground among many of those concerned with protecting the environment. It is considered as core issue of environmental sustainability and development. Poverty alleviation is believed to be the main remedy of environmental degradation in developing countries. Bangladesh is the one of the developing nations with a low resource base and high population density (Bangladesh Planning Commission, 1995). The government and some environmental cognoscenti believe that overpopulation of the country and local people are responsible for depletion of natural resources (Centre for Policy Dialogue, 2002; UNO, 2002). Some scholars suggest that blaming the poor for natural resources degradation may only be partly true. However, the fact is that any degradation of the natural resources first affects the poor by shrinking their access to natural resource bases and livelihood options. Therefore, there is a need to devise pro-poor development strategies (Rahman, Mallick, Haque and Nisat, 2002). Nowadays policy makers, planners, NGOs, as well as international donor agencies are increasingly supporting the notion of poverty alleviation through natural resource management. The government of Bangladesh introduced SF as a response to poverty alleviation, meet up fuelwood crisis and restore ecological balance in the early 1980s and the pioneer SF projects of the country were introduced in the Barind tract. In this chapter, it is posited that assessment of economic benefits and social benefits accrue from SF programmes and analysis of their management practices are central to understanding the outcomes of

SF in relation to its socio-economic objectives. This chapter attempts to evaluate socio-economic outcomes and management practices of some implemented SF projects in the study area.

5.2 Results

5.2.1 Socio-economic Background of the Respondents

5.2.1.1 Gender and Age Pattern

A total of 120 beneficiaries were selected as respondents for this study from the study area. Among them, 79.2% of the respondents were male and 20.8% of the respondents were female. Age is an important determinant to carry out any forestry related activities properly and efficiently. As plantation activities need physical strength, the selection of beneficiaries (Community participants) from a particular age is important for any SF programme. Generally, people tend to be hard working until they arrive at the 45 years of age. People up to this age are always more active than the older ones. It was found that majority of both the male (66.3%) and female (96%) respondents belonged to the age group of 36- 45 years or below this age group (Table 5.1).

Table 5.1: Distribution of Respondents by Gender and Age

Gender	Percent & Number	Age group	Count	Percent	Cumulative Percent
Male	79.2% (95)	15-25	1	1.1	1.1
		26-35	24	25.3	26.3
		36-45	38	40.0	66.3
		46-55	25	26.3	92.6
		56 and above	7	7.4	100.0
		Total	95	100.0	
Female	20.8% (25)	15-25	1	4.0	4.0
		26-35	13	52.0	56.0
		36-45	10	40.0	96.0
		46-55	1	4.0	100.0
		Total	25	100.0	

5.2.1.2 Caste and Religion

The study area is demographically heterogeneous area. Aboriginal peoples especially santals are the one of elements of demographic heterogeneity. Twelve percent of the respondents were selected from ethnic groups. In Bangladesh, Muslims constitute the highest percentage (89.7%) of population in terms of religion (BBS, 2004). Same as the country's religion profile, the highest 76% of the respondents were selected from Muslim community. Seven percent and 5% of the respondents were selected from Hindu community and Christian community respectively (Figure 5.1).

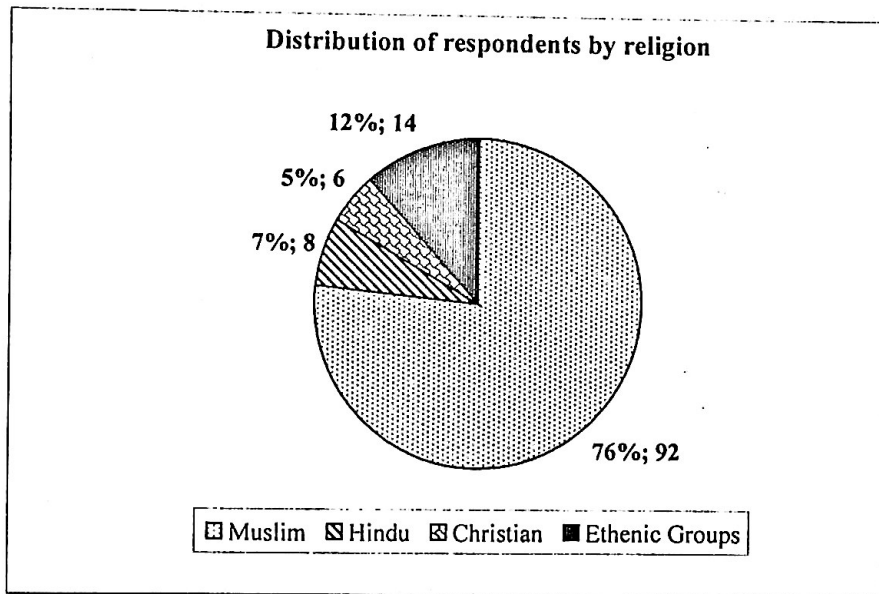


Figure 5.1 Distribution of respondents by religion

5.2.1.3 Family Size and Land Holding Pattern

The mean family size of the respondents was 6.7. The family size in the greater Rajshahi region (Rajshahi, Nawabganj and Naogaon) is 4.67 while it is 5.6 at the national level (BBS, 2004). The land ownership pattern in the HBT is unique in comparison to other parts of the country. It is an important determinant of socio-

economic stratification of the people of the area. About 80% of the total land in the HBT belongs to absentee landlords dwelling in metropolitan cities and they have important role in the overall labour employment. Landless tenants constitute the largest segment of the rural population in the HBT. Most of the tenants live on landlords' land and cultivate lands as share croppers (Torquebiau, 1991). Having an agro based economy, land ownership is considered as one of the important factors in determining poverty situation in the study area. A positive correlation was found between landownership and economic conditions of the respondents (Table 5.2). It supports the relationship between landownership and economic prosperity of the respondents i.e. higher the land ownership, better the economic condition.

Table 5.2: Correlation between Land Ownership and Economic Conditions of Respondents

		Land ownership category	Economic condition
Land ownership category	Pearson Correlation	1	0.487**
	Sig. (2-tailed)	.	0.000
	N	120	120
Economic condition	Pearson Correlation	0.487**	1
	Sig. (2-tailed)	0.000	.
	N	120	120

** Correlation is significant at 0.01 level (2-tailed).

The mean land ownership of the respondents was 73.91 decimals. Among the five different land holding categories, it was found that most of the respondents belonged to the 0.05-.49 acres category (46.7%) and the landless category (17.5%); and these two categories constituted 64.2% of the total respondents. Only 4.2% and 3.3% of the respondents were found in the 2.50-4.99 acres and 5.00+ acres land ownership categories respectively (Table 5.3).

Table 5.3: Land Holding Pattern of Respondents

Group	Frequency	Percent	Cumulative Percent
Landless	21	17.5	17.5
0.05-.49 acres	56	46.7	64.2
.50-2.49 acres	34	28.3	92.5
2.50-4.99 acres	5	4.2	96.7
5.00+ acres	4	3.3	100.0
Total	120	100.0	

5.2.1.4 Educational Status

Education helps to identify, comprehend and resolve problems related to everyday life. In Bangladesh, about half (50.4%) of the adult population (15 years +) is illiterate (BBS, 2004). The situation in the study area was no better than the national level. The study results revealed the reality in this regard. It was found that 50.8% of the respondents were illiterate, 21.7% of the respondents managed to attend several years of elementary level of education, 19.2 % of the respondents attended high school education and 8.3% of the respondents had a chance of joining higher secondary education (Table 5.4).

Table 5.4: Educational Status of Respondents

Level of Education	Frequency	Percent	Cumulative Percent
Illiterate	61	50.8	50.8
Primary	26	21.7	72.5
Secondary	23	19.2	91.7
Higher Secondary	10	8.3	100.0
Total	120	100.0	

5.2.1.5 Economic Conditions of Respondents

It was found that the term 'annual income' did not mean anything to many of the respondents, as they were daily labourers. Moreover, some respondents were conservative to disclose their annual income figure. Therefore, to obtain data about respondents' economic conditions, they were asked to locate themselves in the given economic strata where they fit well. Table 5.5 represents that 40.8% of the respondents located themselves in the always-poor group i.e. they lived in poverty round the year. Next to the always-poor group, 39.2% of the respondents perceived themselves as moderate poor and only 20% of the respondents placed themselves in the middle class economic stratum.

Table 5.5: Economic Conditions of Respondents

Group	Frequency	Percent	Cumulative Percent
Always poor	49	40.8	40.8
Moderate poor	47	39.2	80.0
Middle Class	24	20.0	100.0
Total	120	100.0	

5.2.1.6 Principal and Secondary Occupations of Respondents

The livelihood of people of the HBT is quite different from that of the other areas of Bangladesh. The landless tenants who mainly depend on agriculture constitute the largest segment of the population in the HBT. Traditionally aboriginal people maintain their livelihood as an agricultural labourer; particularly aboriginal women are the integral part of different stages of paddy cultivation in the HBT. Livelihood of most of the beneficiaries was dependent on agriculture. It was found from the field survey

that about 64.2% of the beneficiaries depended on one form of agriculture or another ranging from producing crops on their own lands to selling labour for agriculture or sharecropping. Purely agricultural labour or daily labour was the principal occupation of 30.8% of the respondents. Petty business was the principal occupation of 17.5% of the respondents (Table 5.6).

Table 5.6: Principal Occupations of Respondents

Occupation	Frequency	Percent	Cumulative Percent
Agriculture	40	33.3	33.3
Agri/Day labour	37	30.8	64.2
Business	21	17.5	81.7
Service	2	1.7	83.3
House wife	12	10.0	93.3
Social worker	2	1.7	95.0
Unemployed	4	3.3	98.3
Teacher	2	1.7	100.0
Total	120	100.0	

Due to economic hardship, people of the HBT are forced to earn from more than one source to satisfy their end meet. It was found that 30.8% of the total respondents had secondary sources of income (Table 5.7). Secondary occupations were largely agriculture based (62.1%). If poor beneficiaries' primary occupation were not agricultural labourer, then it was likely to be secondary one. Large number of respondents having petty business as principal occupation engaged in own crop cultivation and share cropping as a secondary occupation, inverse case was also common among the respondents.

Table 5.7: Secondary Occupations of Respondents

Secondary Occupation	Frequency	Percent	Valid Percent	Cumulative Percent
Agriculture	16	13.3	43.2	43.2
Agri/Day labour	7	5.8	18.9	62.1
Business	11	9.2	29.7	91.8
Fishery	1	0.8	2.7	94.5
Poultry	1	0.8	2.7	97.3
Informal service	1	0.8	2.7	100.0
	37	30.8	100.0	
No sec. occupation	83	69.2		
Total	120	100.0		

5.2.1.7 Household Fuel Usage

People of the HBT traditionally use animal dung as a main source of fuel. Zuberi (1998) provided some useful idea on the pattern of fuel usages of Godagari upazila of the HBT (Table 5.8). It is evident from the provided data that contribution of animal dung as fuel is in the highest place, crop residue contributes after animal dung during the wet season, and it goes reverse during the dry season.

Table 5.8: Fuel Use Pattern in the HBT (Godagari upazila) in 1991

Season	Crop Residue (%)	Leaves twigs (%)	Animal dung (%)	Wood (%)
Dry Season (Nov-Apr.)	40.45	14.86	31.1	13.52
Wet Season (May-Oct.)	27.03	6.76	48.65	17.56

Source: Zuberi (1998)

It was found from the field survey that after animal dung, the contribution of crop residues (i.e. straw, rice husk/barns) as cooking fuel came to the second. Fuelwood contributed less than animal dung and crop residues. As illustrated in Table 5.9, it was

found that 46.7% of the respondents used animal dung and crop residues, 23.3 % of the respondents used animal dung and fuelwood, 16.7% of the respondents used only animal dung, and 5% of the respondents used animal dung and kerosene as main sources of cooking fuel. Only 5% of the respondents were found to use fuelwood as a main source of cooking fuel.

Table 5.9: Respondents' Household Fuel Usage

Fuel Types	Frequency	Percent	Cumulative Percent
Animal dung + Kerosene	5	4.2	4.2
Animal dung	20	16.7	20.9
Animal dung + Fuelwood	28	23.3	44.2
Animal dung + Crop residue	56	46.7	90.9
Animal dung + Fuelwood+ Crop residue	6	5.0	95.8
Fuelwood + Animal dung	5	4.2	100.0
Total	120	100.0	

Cattle rearing (especially Cow and Buffalo) is a traditional practice in the HBT for plough and draw carts. Affluent farmers have many cattle heads and they get enough animal dung, which is used as fuel and manure. Landless people and marginal farmers of the area collect it from grazing fields. Use of animal dung as fuel is culturally embedded in the HBT. Crop residues and fuelwood are used as cooking fuel in the dry season together with animal dung and in the rainy season, mainly animal dung is used as cooking fuel. The prime objectives of SF in Bangladesh is to meet the need of fuelwood and forest produce on sustained basis, lessen the dependency on animal dung and make animal dung available as manure for agriculture production (BFD n.d). The results revealed that SF intervention could not able to create considerable impact on the fuel use pattern of the respondents.

5.2.2 Socio-economic Benefits from Social Forestry

The SF projects, which have so far been implemented in the HBT were intended to alleviate poverty through economic development, fuelwood supply and simultaneously were intended to restore ecological balance of the area. Attainment of economic benefits from any development project depends on some of the key criteria: the project objectives fit the needs of the local communities, all the project inputs satisfactorily available at the right time and place and successful management of project implementation barriers. It was observed that none of the above criteria was satisfactorily managed in the implemented SF projects of the study area. Generally, the community needs were ignored. Majority of the respondents mentioned that they were interested in planting of fruit bearing trees in the SF projects and were eager to generate immediate income to support their livelihood. However, their aspiration was not materialised due to implementation of centrally defined SF projects in the study area. In the name of SF, mere afforestation could not serve the purpose of local people as well as local environment. The following comments by the beneficiaries reflect the whole scenario of SF in the HBT.

You see, what they have done. Everywhere you would find 'Sisha Gaach' (Sissoo tree) on both sides of the roads in Nachol area. This tree is sterile. Even birds do not nest on the tree. We the Bengalis culturally do not like sterile living beings. After 10 years of involvement in the strip plantation I haven't got a single paisa (lowest denominating unit of Bangladeshi currency) from it, even I haven't taken a single branch for fuelwood. These SF projects are neither for poverty alleviation nor for environment." (Margina Bibi, Beneficiary of SF project, Muradpur, Nachol, Interview, January 15, 2004,).

Wasn't there any judicious forester in the Forest Department? If they had planted fruit trees instead of exotic species, we would have been getting both monetary benefits and fuelwood by now. Species like Aam (*Mangifera indica* L.), Bel (*Aegle marmelos* (L.) Correa), Kul (*Zizyphus* sp.), Lichu (*Litchi chinensis* Sonn.), Sal (*Shorea robusta* Gaertn.) could be the best choice for afforestation. They tell about fast growing trees, forest cover, and fuelwood etc. Even our Mandar (*Erythrina variegata* L.) could outshine their so-called fast growing trees in all respects." (Moni Barnan, Beneficiary of SF project, Vardandh, Niamotpur, Interview, November, 02, 2003.)

5.2.2.1 Economic Benefit and Utilization Pattern of Monetary Benefit

The survey results showed that the direct economic benefit from SF was insignificant. When asked about the monetary benefit that gained over the last years from participating in the SF projects, 69.2% of the respondents mentioned that they did not get any economic benefit. About 21.7% and 4.2% of the respondents informed that their benefits from SF produce were Tk. 1-200 and Tk. 201-500 respectively. Only 5% of the respondents mentioned that they earned Tk. 1000-4000 from SF produce. Table 5.10 shows that about 26% of the respondents earned only Tk. 0-500, which was not sufficient to support their livelihood and most of the respondents said that they either had donated their stake to local mosque or spent the money by having a community feast. The six respondents (5%) who earned Tk. 1000-4000 spent the money on repayment of loan (2), renovation of houses (2) and family expenditures (2). Although there was provision of cultivation of vegetables and intermediate crops under the plantations in the deed of contract (Dey, 1996), it was found that none of the organisations (FD/NGOs) inspired the beneficiaries to cultivate vegetables and intermediate crops, which could accrue some economic benefit to the beneficiaries.

Table 5.10: Economic Benefit from Social Forestry

Benefit (in Taka)	Frequency	Percent	Cumulative Percent
0-200 Taka	26	21.7	21.7
201-500 Taka	5	4.2	25.9
1000-4000 Taka	6	5.0	30.9
No economic benefit	83	69.2	100.0
Total	120	100.0	

5.2.2.2 Expected Monetary Benefit

Respondents were asked to mention the amount of money they expect from SF after harvesting their participatory plantation plots. About 24% and 32% of the respondents expected that they would get Tk. 10,000-20,000 and Tk. 21,000-40,000 respectively. Expectation of 22.5% of the respondents was Tk. 41,000-60,000 and expectation of about 10% of the respondents was Tk. 61,000-80,000. About 9% of the respondents hoped for the highest amount of Tk. 81,000-100,000 (Table 5.11).

Table 5.11: Expected Monetary Benefit from Social Forestry

Range (Taka)	Frequency	Percent	Cumulative Percent
81,000-100,000	11	9.2	9.2
61000-80000	12	10.0	19.2
41000-60000	27	22.5	41.7
21000-40000	38	31.7	73.4
10000-20000	29	24.2	97.5
No benefit	3	2.5	100.0
Total	120	100.0	

It was found that 100% respondents were in dark about the extraction and marketing process of forest produce. Some of the beneficiaries opined that exclusion of beneficiaries from the extraction of forest produce and the valuation process was frustrating. A good percentage of respondents (76.67%) opined that they would not get the fair price of forest produce as they are not taking part in the valuation process of the forest produce (Table 5.12).

Table 5.12: Opinion of Respondents about Getting Fair Price of Forest Produce

Parameter	Frequency	Percentage
Yes	92	76.67
No	28	23.33
Total	120	100

In the project performance report of 'Community Forestry Project', it was commented that the FD had failed to devise proper methodologies for felling the mature trees and sharing them with the concerned people in all the project areas (ADB, as cited in Huq and Alim, 95). The scenario remains the same after a period of 11 years. One of the beneficiaries expressed his frustration to the researcher in such a manner:

I had been looking after a one-hectare woodlot plantation of Akasmoni (*Acacia auriculiformis* A. cunn. ex Benth.) sponsored by the Forest Department since 1990-91. The trees were mature enough for extraction two years back from now. I had been appealing the forester to harvest the trees and sale the produce to the market. He was dilly-dallying because he had to get permission and quota to extract forest produce. One day he informed me that the trees had already been auctioned. The price of the trees had been fixed at Tk. 88,000 and I would get half of the amount. I don't know how they fixed the price. It would be better if I could join in the decision making process." (Baharul Islam, School teacher and Beneficiary of SF project, Chandoir, Niamotpur, Interview, August 09, 2004).

5.2.2.3 Intangible Benefits

Respondents were asked to rank the intangible benefits derived from SF according to the degree of benefit he/she thinks the best. It was found that the highest score went up to the broadening of environmental awareness due to SF intervention and it was ranked in the 1st place. Considerable number of respondents opined that they felt more secure in terms of social security and they became more united after joining SF, thus increase of social security was ranked in the 2nd place. Social prestige of the respondents enhanced in the society after joining SF was ranked in the 3rd place. Improvement of social harmony, increase of employment opportunity and broadening of political awareness were ranked in the 4th, 5th, and 6th places respectively (Table 5.13).

Table 5.13: Ranking of Major Intangible Benefits Derived from Social Forestry

Intangible Social Benefits	P (N)	P (N)	P(N)	P (N)	P (N)	P (N)	Total point	Rank
Beneficiaries become united and feel more secure	240(40)	215(43)	136(34)	9(3)	0(0)	0(0)	600	2 nd
Prestige enhanced in the society	66(11)	45(9)	244(61)	108(36)	4(2)	1(1)	468	3 rd
Improvement of social harmony	30(5)	30(6)	36(9)	237(79)	38(19)	2(2)	373	4 th
Broadening of environmental awareness	360(60)	260(52)	32(8)	0(0)	0(0)	0(0)	652	1 st
Broadening of Political awareness	12(2)	30(30)	16(4)	6(2)	36(18)	88(88)	188	6 th
Employment opportunity increased	12(2)	20(4)	16(4)	0(0)	162(81)	29(29)	239	5 th

N= No. of respondent, P= Point.

Note: Points were determined on the basis of intangible benefit ranked by the respondents. Suppose six respondents ranked a social benefit 'Prestige enhanced in the society' as 1st, 2nd, 3rd, 4th, 5th and 6th places respectively, then the total point of this particular problem would be (6+5+4+3+2+1)= 21.

5.2.2.4 Fuelwood Supply from Social Forestry

One of the common objectives of earlier SF projects elsewhere in the world as well as in Bangladesh was to increase availability of fuelwood. The deteriorating environmental condition of the Barind tract compelled the planners and policy makers to establish earlier SF projects. It was presumed that poor people rely on fuelwood for their energy need that resulted to the depletion of natural vegetation and desertification of the Tract. As a remedy of fuelwood crisis the fast growing tree plantation was suggested by the donor agencies to meet the fuelwood gap of the area. It was apparent from this investigation that the issue of fuelwood crisis in Barind tract was exaggerated.

The disappearance of natural vegetation was the result of clearance of lands for paddy cultivation. About 55% of the Barind lands were covered by forests in 1849. By 1974 about 70% lands of tract had been changed into cultivable land (Ahamed, 2003). The rationale to plant fast growing exotic monocultures did not serve the prime needs of the people involved in SF projects. The actual needs of many respondents were food security, alternative sources of income and health care support. The result of the field survey demonstrated the insubstantiality of fuelwood crisis (Table 5.14). Respondents were asked to mention whether or not they felt fuelwood scarcity in their everyday life. About 81% of the respondents replied in negative and about 19% of the respondents replied in affirmative.

Table 5.14: Respondents' Feeling about Fuelwood Scarcity

	Frequency	Percentage
Feel fuelwood scarcity in everyday life	97	80.83
Don't feel fuelwood scarcity in every day life	23	19.17

While the researcher was interviewing a group of female beneficiaries at Niamotpur, commenting on their basic needs Barati Rani, the president of a local women beneficiary group echoed the opinion of her group members as follows:

Here, you can see paddy fields miles after miles. But we the labourers get very little for our subsistence. We are in sheer poverty round the year. Sometimes drought worsens our existing hardship. First of all, we need food security and alternative sources of income. ... My first and foremost appeal to the government and other authorities to make such environment so that *Amar sontan jeno thake dudhe-bhate* (May my children live in affluence in future). We the people of this area plant trees for fruits, so that our children can grow up healthily. Every mother feels pleasure to see her children eat fruits. If you plant fruit trees it would automatically give you plenty of leaves and branches for cooking and you can earn a lot by selling the excess fruits (Barati Rani, Beneficiary of SF project, Dharampur, Niamotpur, Interview, April 16, 2004).

The respondents were asked to mention their annual consumption of fuelwood that came from their plantation plots. More than 84% of the respondents mentioned that they did not get fuelwood from SF projects. Ten percent and 5% of the respondents mentioned that they got 5-25% and 26-50% of fuelwood from SF respectively. Only one respondent mentioned that he obtained 76-100% fuelwood from SF of his annual fuelwood consumption (Table 5.15). One positive economic aspect was observed during the field survey that, many poor women and children use their brooms to sweep up and collect dry leaf litter from the SF project areas for cooking. But this type of brooming the litter decreases the humus formation in SF floor (Rahman, 2005).

Table 5.15: Contribution of Social Forestry to the Beneficiaries' Annual Fuelwood Consumption

Fuelwood Obtained From Social Forestry	Frequency	Percent	Cumulative Percent
Didn't get fuelwood from SF project	101	84.2	84.2
5% to 25%	12	10.0	94.2
26% to 50%	6	5.0	99.2
76% to 100%	1	.8	100.0
Total	120	100.0	

5.2.2.5 Respondents' Priority to Join in Social Forestry

Respondents were asked to rank the causes, which encouraged them to join in Social Forestry as a beneficiary (Community participants). It was found that allure of economic benefit inspired respondents the most to join in the SF projects and they ranked it in the 1st place. Ranking of environmental restoration through SF was in the 2nd place and rankings of fuelwood, food and fodder were in the 3rd, 4th, and 5th places respectively (Table 5.16).

Table 5.16: Respondents' Priority to Join in Social Forestry

Cause of Joining	P(N)	P(N)	P(N)	P(N)	P(N)	Total Points	Rank
Economic Benefit	380(76)	120(30)	54(18)	4(2)	2(2)	560	1 st
Environmental Restoration	125(25)	200(50)	93(31)	26(13)	12(12)	456	2 nd
Fuelwood	55(11)	112(28)	153(51)	44(22)	36(36)	400	3 rd
Food	30(6)	8(2)	33(11)	160(80)	24(24)	255	4 th
Fodder	10(2)	40(10)	27(9)	6(3)	46(46)	129	5 th

P= Point, N= No. of respondent

Note: Points were determined on the basis of priority ranked by the respondents. Suppose five respondents ranked 'food' as 1st, 2nd, 3rd, 4th, and 5th places respectively as a cause of joining Social Forestry, then the total point of this particular cause would be $(5+4+3+2+1 = 15)$.

5.2.3 Management Aspects of Social Forestry

5.2.3.1 Beneficiary Selection

Voluntary participation, self-motivation and transparency in the beneficiary selection process play an important role in the successful management of SF. The results revealed that there were multidimensional anomalies in the Beneficiary selection process. The nature of the problems was quite different in the FD managed projects than NGOs managed projects. In case of the FD sponsored SF projects, there are provisions that, FD will select beneficiaries in consultation with the local governmental organisations and NGOs associated with SF. The beneficiaries would be mandatorily drawn from disadvantaged or vulnerable socio-economic strata. The assignment of NGOs in the SF projects is to organise, motivate and provide training to the beneficiaries. In the field survey, it was found that there was no NGO activity in any FD-sponsored SF project. One hundred percent respondents of the FD-sponsored SF projects mentioned that they did not get NGOs' help. About 58% of the respondents of the FD sponsored SF projects mentioned that they were selected by the

recommendation of Members of Local government (MLG) or local elites and 35% of the respondents mentioned they were directly selected by the FD officials. Only 5% of the respondents mentioned, they took self-initiative to be a beneficiary of SF project. In NGO sponsored SF projects it was found that all of the beneficiaries (100%) were drawn from pre-selected micro credit groups and the prime activities of these groups were other than SF (Table 5.17).

Table 5.17 Selection Process of Beneficiary in Social Forestry projects

Type of sponsorship	Selected By	Frequency	Percent	Cumulative Percent
FD sponsored	Self initiative	3	5.0	5.0
	Directly by FD officials	21	35.0	40.0
	Recommended by MLG or local elites	35	58.33	98.33
	As a Member of Club/Society	1	1.7	100.0
	Total	60	100.0	
NGO sponsored	Pre-selected for micro-credit group	60	100.0	100.0

5.2.3.2 Role of Women in Social Forestry

Traditionally women play an important role in seed management, selection of species, pre-planting and harvesting of non-wood forest products (leaves, root, fruit etc.). They have better knowledge in using, conservation and processing of plant materials. A study on gender roles in homegarden management in Bangladesh showed that women contributed 30-40% of their active time in homegarden production system, whereas farmers spent only 4.8-12.2% of their labour in homegarden management (Mustafa, 1997). It is essential to utilise the knowledge of conservation of women in the management of SF. In rural Bangladesh, involvement of women in outside activities

is quite limited. Beyond fuel collection and fetching water, women do not go outside of their home. A woman's involvement in outside activities is seen as non-prestigious for family. However, some communities permit women to work outside home particularly poor women who have no alternatives. Involvement of women in SF was found rather superficial in the study area. It was found that the FD officials, NGO officials and male members of the families enlisted female name in the LCOs as a beneficiary for the sake of SF project regulations and micro credit disbursement while male relatives remained the actual beneficiary in the guise of female name. The result showed that 52% of the female respondents involved actively in the SF projects and 48% of the female respondents admitted that their male relatives worked for them (Table 5.18).

Table 5.18: Involvement of Woman Beneficiaries in Social Forestry

Nature of Involvement in SF	Count	Percent
Actively involved	13	52.0
Male relatives work for the women beneficiary	12	48.0
Total	25	100.0

* All respondents are female

5.2.3.3 Training

Afforestation through SF is rather a new technology in the forestry sector, which is related to all of the environmental components as well as local people. Development of a knowledge base is essential for sustainable SF management while practicing the technology as it encompasses environment and people. Therefore, training is an important part of SF project management. It was found that majority of the respondents were not trained. Non-trained respondents from the FD and NGOs were 63.3% and 68.3% respectively (Table 5.19).

Table 5.19: Distribution of Respondents by Training Obtained

Type of operation		Frequency	Percent	Cumulative Percent
FD	Trained	22	36.7	36.7
	Non-trained	38	63.3	100.0
	Total	60	100.0	
NGO	Trained	19	31.7	31.7
	Non-trained	41	68.3	100.0
	Total	60	100.0	

5.2.3.4 Selection of Species and Species Composition in Social Forestry Projects

Participation of community people during the selection of species for plantations is one of the cornerstones of ensuring people's participation in SF. The selection of plantation species depends on the needs of the participants, local knowledge and climatic conditions of an area. Table 5.20 lists the results regarding participation of beneficiaries in species selection. It was found that 85.8% of the respondents did not participate in the species selection process. The project authorities centrally chose the plantation species. About 11.7% of the respondents mentioned that implementing organisations discussed with them while selecting the plantation species. Only 2.5% of the respondents mentioned they themselves selected the plantation species for their SF plots.

Table 5.20: Respondents' Participation in Species Selection

Species selection process	Frequency	Percent	Cumulative Percent
FD/NGOs centrally selected species	103	85.8	85.8
Respondent himself selected species	3	2.5	88.3
Respondent + Organisation	14	11.7	100.0
Total	120	100.0	

It was observed that there was a general repugnance among respondents and local people to Sissoo tree (*Dalbergia sissoo* Roxb.). Table 5.21 provides the picture of species planted in respondents' SF project areas. In the Strip plantations, majority (82.1%) of the respondents mentioned that Sissoo (*Dalbergia sissoo* Roxb.) was planted in their SF project areas. Combinations of Sissoo (*Dalbergia sissoo* Roxb.), Mehogany (*Swietenia mahagoni* (L.) Jacq.), Ipil Ipil (*Leucaena leucocephala* (Lamk.) de Wit.) and Eucalyptus (*Eucalyptus* sp.) were planted in 13.4% of the respondents' SF project areas, where Sissoo (*Dalbergia sissoo* Roxb.) was the dominant species. Only 4.5% of the respondents mentioned that the combination of Arjun (*Terminalia arjuna* (Roxb.) Wt. & Arn), Mango (*Mangifera indica* L.), and Babla (*Acacia nilotica* (L) Del.) was planted in their SF project areas, where Arjun (*Terminalia arjuna* (Roxb.) Wt. & Arn) was the dominant species. In case of the woodlot plantations, 100% respondents informed that Akasmoni (*Acacia auriculiformis* A. Cunn. ex Benth.) was the only plantation species in their SF project areas.

Table 5.21: Species Combination of Respondents' Social Forestry Areas

Type of Plantation	Species	Frequency	Percent	Cumulative Percent
Strip Plantation	Sissoo	92	82.1	82.1
	Sissoo+Mehogoni+Babla+Ipil Ipil+Eucalyptus	15	13.4	95.5
	Arjun+Mango+Babla	5	4.5	100
	Total	112	100.0	
Woodlot Plantation	Akasmoni	8	100.0	100.0

5.2.3.5 Respondents' Preference of Species for Future Social Forestry

The respondents were asked to rank five tree species according to their preference for future SF projects. Thirty-six tree species were cited by the respondents; among them most of the species were fruit species. The respondents ranked Aam (*Mangifera indica* L.) in the first place, Kul (*Zizyphus mauritiana* Lamk.) in the 2nd place and Litchu (*Lichi chinensis* Sonn.) in the 3rd place as their preference for future SF projects. Appendix L shows the ranking of preferred species by the respondents.

5.2.3.6 Problems of Social Forestry Perceived by Beneficiaries

The respondents were asked to mention the problems that they think largely thwarted the implementation of productive SF. It was found that 28.3% of the respondents mentioned low economic benefit from SF, 21.7% of the respondents mentioned trees were stolen, 17.5% of the respondents mentioned thinning, pruning and harvesting of trees were not done properly, and 15.8% of the respondents mentioned grazing as the main constraint of productive SF projects. The detail results are shown in Table 5.22. The results revealed that the respondents mainly identified the problems related to management approach.

Table 5.22: Constraints of Social Forestry

Nature of Problems	Frequency	Percent	Cumulative Percent
Grazing	19	15.8	15.8
Trees are stolen	26	21.7	37.5
Non co-operation of the FD & NGOs	15	12.5	50.0
Low economic benefit	34	28.3	78.3
Conflict among group members	1	.8	79.2
Scarcity of land for plantation	4	3.3	82.5
Thinning, pruning & harvesting of trees are not done timely	21	17.5	100.0
Total	120	100.0	

5.2.3.7 Suggestions for Productive Social Forestry practice

The three major problems such as low economic benefit; late thinning, pruning and harvesting of trees and non co-operation of the FD and NGOs as encountered by the respondents were the inbuilt management glitches of the SF projects. Although grazing and thefts of trees were external problems; proper supervision of the projects and animated participation of respondents could have solved these problems. Respondents of this study suggested six different remedial measures to be adopted to address the existing problems of SF practice. Species should be selected in consultation with beneficiaries was the suggestion of 30% of the respondents. Intermediate crops, short rotation trees should be introduced together with long rotation trees was the suggestion of 21.7% of the respondents. More than 18% of the respondents suggested for timely thinning, pruning and harvesting of trees and timely distribution of forest produce. Another 17.5% of the respondents suggested for employment of caretakers for extended time and regularise their salary (Table 5.23).

Table 5.23: Suggestions of Respondents for Productive Social Forestry

Nature of Remedy	Frequency	Percent	Cumulative Percent
Timely thinning, pruning and harvesting of trees and ensure distribution of benefit to the participants.	22	18.3	18.3
Representatives of local govt. should be included in the beneficiary selection process	5	4.2	22.5
Intermediate crops, short rotation trees should be introduced along with long rotation trees	26	21.7	44.2
Employ caretakers for extended time & regularise their salary	21	17.5	61.7
Selection of species should be consulted with beneficiary	36	30.0	91.7
Ensure administrative help to protect tree pilferage	10	8.3	100.0
Total	120	100.0	

5.3 Discussion

5.3.1 Socio-economic Benefits of Social Forestry

Poverty alleviation is one of the core objectives of SF in Bangladesh. The results revealed that this particular core objective was not realised satisfactorily. According to Table 5.10, about 69% of the respondents did not get any monetary benefit and about 22% of the respondents got meagre amount of benefit, which were not enough to improve livelihoods of the beneficiaries. Most of the beneficiaries opined that if the project authorities planted fruit bearing multipurpose trees instead of exotic species they would have got enough cash money, food and fuel from these trees within three years of plantation. Even within existing management regimen, timely thinning-pruning of the trees and cultivation of vegetables/intermediate crops or plantation of short rotation plants could accrue some economic benefits and could supply fuelwood to the beneficiaries. None of the organisations involved in SF did bother to follow the provisions written on the project profiles of respective SF projects. Majority of the respondents (97.5%) expected that they would get a considerable amount of economic benefit from SF, when the trees would finally be harvested (Table 5.11). With the raising rays of hope, there were dark patches in their mind because about 77% of the respondents feared that they would not get the rational price of their forest produce (Table 5.12). According to the SF rules, the decision on some important matters such as intermediate products extraction time, harvesting time, market the product, price fixing and so forth are totally vested on the Bangladesh Forest Department while the onus of these issues falls on the beneficiaries (Roy and Halim, 2001). It was observed that hundred percent respondents did not know anything about the procedures of harvesting, valuation and marketing of their forest produce and there was every possibility of deprivation in getting fair price of forest produce.

Regarding intangible benefits from SF, the result indicates that SF has brought about a positive change of beneficiaries' attitude and thinking towards environment. While asked to rank intangible benefits from SF, the respondents ranked broadening of environmental awareness in the first place (Table 5.13). Many respondents admitted to the researcher that, before joining as a beneficiary in the SF projects they did not know the inherent causes of rainfall, drought, land degradation and importance of afforestation etc. After joining the SF programmes, they became well concerned about environment.

SF projects were established to redress the environmental deteriorating condition of the study area and reduce over exploitation of biomass (i.e. animal dung, crop residue, natural vegetation) as fuelwood. The fuelwood crisis was depicted as one of major causes of environmental deterioration of the tract. It was revealed from the field exploration that in the formulation and implementation stages of SF projects, there was lack of sincerity while assessing the local needs. In the name of fuelwood crisis and ecological restoration, environmental problems of the Barind tract was pegged with the fuelwood crisis of drought prone Shaelian Africa or elsewhere of the world that was prevailing in the late 1970s and early 1980s. Local knowledge, local needs and environmental considerations were suppressed by the much hyped fuelwood crisis. This should not be interpreted as an argument that environmental problems and fuelwood shortages do not exist in the study area. They do exist, often on a widespread scale. However, over emphasis on fuelwood production as a panacea for rejuvenation of environment suppressed local knowledge based potential sustainable approaches. Arnold (1992) expresses similar view as: "The focus on fuelwood has also diverted attention from other roles of trees within the rural household economy, and has obscured the other considerations that enter into women's and men's decisions about tree growing" (Chapter 2, "Peoples Dependence on Forests and Trees"). It was found

that 95.8% of the respondents used animal dung as a main source of cooking fuel and only 4.2% of the respondent used fuelwood as a main source of their cooking fuel (Table 5.9). The results indicate that though there were various interventions regarding lesser use of animal dung as fuel and using it as manure to increase the biomass proportion of soil in the HBT, it remained a major fuel source of the area. It was also found that about 81% of the respondents did not feel fuelwood scarcity in their every day life while only 19% of the respondents mentioned that fuelwood scarcity is a problem in their every day life (Table 5.14). Furthermore, about 84% of the respondent mentioned they did not get any fuelwood from their respective SF projects (Table 5.15). Considering the results of the field survey regarding fuelwood it may be concluded that SF projects in the study area had failed to fulfill their much-hyped assignment- the 'Fuelwood supply'.

The results regarding cause of joining the SF projects as beneficiary substantiates that objectives of any development interventions should be assessed from the grass-root level rather than imposed from the top. Table 5.16 shows that respondents of this study prioritised economic benefit (ranked in 1st Place) and environmental restoration of the area (ranked in 2nd place) over fuelwood supply as cause of joining the SF projects. The results conform to the existing socio-environmental situations of the tract. The poor people of this tract are in dire need of alternative sources of income as they are unable to maintain their livelihood only from agriculture. The respondents assumed that SF could be their alternative sources of income although their hope was not fulfilled. The HBT is drought prone area of the country, vegetation cover is very sparse, climate is extreme in nature, and people have to face scarcity of rain often. This could be the reason behind the ranking of environmental restoration through SF in the 2nd place.

5.3.2 Management Aspects of Social Forestry

Social Forestry or community forestry projects in Bangladesh were envisaged practicing the bottom up management approach in writing. The central tenet of Social Forestry is “forestry for the people and involving the people and it must be forestry which starts at the ‘grass roots’” (FAO, 1978, Part I, “Introduction”). This tenet could not create any appeal to the project formulation and implementation authorities in Bangladesh. The SF projects implemented so far in the study area always followed the top-down management system.

Regarding beneficiary selection, it was found that there was violation of set criteria in the selection of beneficiary by both the FD and NGOs. According to different SF projects’ rules and regulations, beneficiaries of a SF project shall be selected from the landless farmers, destitute women and other disadvantaged groups of people. It is hoped that socio-economic conditions of these groups of people would be changed through the benefit from forest harvests. As per socio-economic conditions of people, Rajshahi region is the poorest region of the country. About 47% people live below the lower poverty line, which is pathetic than the country average of 34% (Ministry of Finance, 2004). The results from Table 5.1 to Table 5.7 show that socio-economic conditions of the respondents were beyond the national average, even sometimes it goes beyond the regional average. The highest percentage of beneficiaries was found in the age group of 34-45 years; and about 79% of the respondents were male and 21% of the respondents were female. About 77% of the respondents were Muslim by religion. The family size of the respondents was 6.7, which was greater than regional and national levels. About 64% of the respondents were landless or functionally landless (owner of below 0.5 acres of land). Majority (80%) of the respondents identified themselves in the

always poor to moderately poor economic strata and there was positive correlation between landownership and economic conditions of the respondents. More than half of the respondents were illiterate. About 64% of the respondents maintained their livelihood on agriculture or as an agricultural/day labourer. The above depiction of socio-economic background of the respondents seems to some extent suit with the SF rules and regulations to be a beneficiary of SF projects. However, in reality there were hidden discrepancies in the selection process of beneficiaries. Lack of transparency and democratic norms in the selection process excluded the neediest members of the communities. It was observed that in most of the cases, the FD officials delivered the responsibility of beneficiary selection to the local elites such as members of local govt. (MLG), local politicians or local influential persons. These elite people tried to select those people with whom he had close personal relationship or patron-client relationship. Due to landownership pattern and scarcity of employment opportunity, patron-client relationship is conspicuous in the study area. The local elites (patrons) are employer of agriculture or other business sectors. The clients are dependent on patrons for work. They work as agriculture labourers or share-croppers in patron's field. Clients are usually used as support bases of local political and power struggle of their patron. Some studies on SF elsewhere in the country also reported similar type of patron-client relationship in case of FD sponsored SF projects (Khan, 2001b; Chowdhury, 2004). It was found that 58% of the beneficiaries of the FD-sponsored SF projects were selected by the recommendation of MLG or local elites and 35% of the respondents were selected directly by the FD officials (Table 5.17). In case of NGO-sponsored SF projects, 100% beneficiaries were selected from the target groups of respective NGOs. Originally, they were organised for micro-credit programmes, later they were given responsibility to look after SF projects. Therefore, in NGO-sponsored SF projects, the

selected beneficiaries did not represent the neediest section of the communities. Thus, the results indicate that the neediest segment of people of the communities was virtually left out from the SF projects in the study area.

Participation of women in SF was superficial in the study area. Regarding women participation in two Nepalese panchayats, Hobley (1990) observes that although intent of SF is to help poor and women. Class and patriarchal structure of the society limit their access to the natural resource bases and their participation in SF projects. The result of this study regarding women's participation in SF supports Hobley's observation. From the field survey, it was found that about half of the female respondent (48%) did not take part actively in SF activities. Their male relatives enlisted their name for the sake of maintaining rules and regulations of SF projects but the actual beneficiary remained the male relatives (Table 5.18).

In case of species selection and species composition, beneficiaries had a very limited opinion in decision-making and they were rarely consulted. Virtually there was no mechanism to accommodate beneficiaries' opinion and ideas in project planning and decision-making phases. The FD and NGOs took all the major decisions regarding species composition and silvicultural practices. Eighty six percent of the respondents mentioned that the FD and NGOs centrally selected species for SF projects (Table 5.20). This result was also supported by the existing species composition of respondents' SF areas. In case of the strip plantations, 95.5% of the respondents mentioned Sissoo (*Dalbergia sissoo* Roxb.) as dominant species in their SF project area and 100% respondents involved in the woodlot plantations mentioned Akasmoni (*Acacia auriculiformis* A. cunn. ex Benth.) was the only species in their SF project area. (Table 5.21). A Study conducted by Khan and Begum (1997) on SF at Chandra, Modhupur showed

that beneficiaries' participation in decision-making and project evaluation were negligible. It concurs with the result of this study. Davidson (2000) found dismal results of five case studies of SF projects implemented in different areas (Altukdhuti, Madhyapara, Tetulia, Chandra, and Betagi/Pomora) of Bangladesh. In most cases there was no true participation. Trees were well past their planned harvest date and no thinning, pruning of trees were made. Economic returns of these projects were negligible. The situation of the SF projects in the study area was no better than the above-mentioned projects. Respondents of this study identified low economic benefit (28.3%), theft of trees (21.7%), no arrangement of timely thinning-pruning and harvesting of forest produce (17.5%) and lack of co-operation from the FD and NGO staffs (12.5%) as the major constraints of productive SF practices (Table 5.22). Beneficiaries' suggestion regarding productive SF practice represents their aspiration to design SF as a source of alternative income. Accommodation of beneficiaries' opinion during selection of species; cultivation of intermediate crops, plantation of short rotation trees along with long rotation trees; timely thinning-pruning and harvesting of trees were the main suggestions for productive SF practice (Table 5.23). The suggestion for cultivation of intermediate crops and planting of short rotation species along with long rotation came owing to the necessity of getting continuous supply of food and forest produce. Some of the suggestions given by the respondents seem worthwhile for the formation of future SF projects in the study area. The top five recommended species for the future SF projects were Aam (*Mangifera indica* L.), Kul (*Zizyphus mauritiana* Lamk.), Litchu (*Litchi chinensis* Sonn.), Peyera (*Psidium guajava* (L.) Bat.), and Nim (*Azadirachta indica* A. Juss.). Most of the species they suggested were native species and suitable for multipurpose usages including food, fuelwood, fodder, economic and medicinal values. Abedin *et al.* (1988) observes that the selection of species grow on

the homestead depends on people's needs and experience of growing trees. There is a close relationship between preferred tree species and household needs. People generally prefer the trees and shrubs that meet the household needs. The result showed that the factors for choosing species by the respondents were a blending of their experience, local agro-climatic conditions, their needs for subsistence, local culture and many other factors. Their preference was not only for fuel; rather they preferred these species so that they could accrue quick and considerable economic returns together with other multiple benefits. The results of the Appendix L support this intention. For instance, the respondents ranked Aam (*Mangifera indica* L.) and Litchu (*Litchi chinensis* Sonn.) in the top five because these two species grow well in the greater Rajshahi region and the region is famous for these two particular species all over the country. Moreover, one can depend on these two species for his economic security. In Rajshahi region people believe in the popular saying "If you have a mature mango tree you needn't to have a son to look after you". The respondents ranked Kul (*Zizyphus mauritiana* Lamk.) in the 2nd and Peyara (*Psidium guajava* (L.) Bat.) in the 4th place. The probable reason behind these ranking may be short gestation period of these species. The fruiting stage of these species is relatively earlier than other fruit tree species and people can harvest fruits within 2-3 years, which is helpful for their subsistence and livelihood. Furthermore, these species can grow well in the semi arid environment like the High Barind Tract.

Uphoff, Cohen and Goldsmith (as cited in Khan and Begum, 1997) suggest that four types of participation are needed for proper project functioning. They are as follows: 1) Participation in decision-making, 2) Participation in project implementation, 3) Participation in benefits, and 4) Participation in evaluation of project activities. It is evident from the previous sections of this chapter that, beneficiaries were not included in the decision-making and implementation stages of the SF projects so far

implemented in the study area. Except some marginal benefits, the envisaged benefits from SF projects were not attained. The beneficiaries had hardly any participation in the project evaluation. There was no such mechanism exists that includes the beneficiaries in the project appraisal process. The responsibilities regarding monitoring and evaluation were bestowed on the FD and NGOs. It is apparent from the above sections that objectives and priorities of the implemented SF projects in the study area were defined from the top that did not reflect the priorities and needs of the communities, local realities as well as local environment. Meaningful participation by the communities during all the stages of project management has proven elusive. In most cases, people who were supposed to identify the problems and determine the priorities, project objectives and activities were not among the decision-makers. In-depth understanding of local needs, precise mechanism for participation of community people in the decision-making and implementation stages, and evaluation of the project activities should have been ensured for true SF practices. Therefore, the objectives of SF in the study area regarding poverty alleviation and people's participation have only marginally been achieved and there is room for a more responsive practice to improve outcomes of SF in the study area.

Chapter Six

Conclusions & Recommendations

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the data analysis results and discussions in the preceding chapters the conclusions of the study are presented as follows:

Objective 1: To measure the impact of extended afforestation programmes on some soil properties.

Research question 1: What is the effect of plantation on soil fertility?

Generally plantations had beneficial effects on the soil fertility. Content of some soil fertility parameters were found higher in the soils of the plantation sites than their respective Non-plantation sites. But the direction and magnitude of soil fertility improvement were species dependent.

Research question 2: Does soil fertility differ in relation to exotic and native plantation species?

The magnitude of some important soil nutrient depletion in *Dalbergia sissoo* Roxb. and *Acacia auriculiformis* A cunn. ex Benth. plantation sites were higher than the native-mixed plantation site. The results showed that the *Acacia auriculiformis* A cunn. ex Benth. plantation promoted soil acidification . The performance of native-mixed plantation (*Terminalia arjuna* (Roxb.) Wt. & Arn and *Mangifera indica* L.) was better than the exotic monoculture plantations of Sissoo (*Dalbergia sissoo* Roxb.) and Akasmoni (*Acacia auriculiformis* A cunn. ex Benth.) in soil fertility improvement.

Objective 2: To determine the species composition, qualitative characters and phytodiversity of the understorey flora in the exotic and native plantation sites planted under Social Forestry projects.

Research question 3: Do the overstorey plantation species have impacts on understorey species composition?

Overstorey plantation species dictated the understorey species composition. The understorey plant communities in the three plantation sites were different from each other. In *Dalbergia sissoo* Roxb. plantation site the total number of plant species was 26, in *Acacia auriculiformis* A. Cunn. ex Benth. plantation site it was 30 and in native-mixed plantation site, the total number of species was 42. A total of 9 species were found common in the three sites during the study period. The total number of species and total number of individual plants were found to vary from season to season in all the sites. It was maximum during the rainy season and minimum during the winter season. As regards the dominance and regular distribution of the species, it was observed that in *Dalbergia sissoo* Roxb. plantation site, *Brachiaria sp* and *Evolvulus nummularius* L. were dominant and regularly distributed during the three seasons. In *Acacia auriculiformis* A. Cunn. ex Benth. plantation site, *Oplismenus compositus* (L.) P. Beauv. and *Brachiaria sp* were dominant during the rainy season, and in the winter season *Cynodon dactylon* Pers. and *Evolvulus nummularius* L. were the dominant species. In the summer season, *Isachne miliacea* Roth. and *Eleusine indica* (L.) Gaertn. were the dominant species. In native-mixed plantation site, *Eleusine indica* (L.) Gaertn. and *Evolvulus nummularius* L. were found to be dominant in all the three seasons.

The floristic composition of the three sites was distinct from each other and Jaccard's community co-efficients were found relatively low in the three pairs of sites. The result of the study showed that the three sites were in the primary

successional state. The presence of naturally regenerated tree seedlings and shrub species were higher in native-mixed plantation site than *Dalbergia sissoo* Roxb. and *Acacia auriculiformis* A cunn. ex Benth. plantation site. This result indicated that the understorey flora of native-mixed plantation site was in more advanced successional stage than that of the understorey flora of exotic monoculture plantations. This was probably due to superior edaphic characteristics and micro-climatic factors of the native-mixed plantation site, which eventually depended on the over storey tree species.

Research question 4: Does understorey phytodiversity differ in relation to exotic and native plantation species?

The understorey flora of native-mixed plantation site was more diverse and rich in species composition. The result of analyses of variance revealed that the number of species showed significant differences at 5% level in case of sites and seasons. The Shannon's diversity index and evenness index values of native-mixed plantation site were the highest among the three plantation sites involved.

Objective 3: To evaluate the perception of beneficiaries about the impact of afforestation on some environmental parameters.

Research question 5: What are the perceptions of beneficiaries about the impact of Social Forestry on soil, temperature, rainfall, flora and fauna of the study area?

The perceptions of beneficiaries about the impact of Social Forestry were positive in case of temperature, rainfall and prevention soil erosion while their perceptions were negative in case of soil fertility, diversity of different plant groups, diversity of birds and number of birds.

Objective 4: To assess the economic and social outcomes of Social Forestry.

Research question 6: What is the extent of economic and social outcomes of Social Forestry?

Social Forestry practice in the study area has failed to materialise its stated objectives-poverty alleviation and fuelwood supply. Economic and social benefits of Social Forestry were marginal. About 69% of the respondents did not get any monetary benefit and 22% of the respondents got meagre amount of benefit. It was found that about 84% of the respondents mentioned that they did not obtain fuelwood from their respective SF projects.

Objective 5: To analyse the management practice of Social Forestry programmes.

Research question 6: What are the management drawbacks of Social Forestry programmes in the study area?

There was no room for active participation of the beneficiaries in the different stages of project management. The performance of Social Forestry in achieving the participatory goal was poor. Implemented Social Forestry projects in the study area were not meant for the need of the local people and local environment. These were rather centrally defined and imposed, and only marginally worthwhile to the people and the environment of the study area.

6.2 Recommendations

- 1) The results of this study show that performance of plantation tree species differs in restoring ecology and soil attributes. Therefore, precautions should be needed in case of selection of plantation species. The choice of species needs careful consideration and should be based on knowledge of the species' effects on soil attributes and local biodiversity. Native multipurpose species could be the best choice for plantation in future Social Forestry projects.
- 2) Beneficiary selection should be more transparent. Multilateral selection committee comprising of representatives from the FD, NGOs, local Governments and local professional groups (school teachers, imams etc.) could be the possible solution in lessening discrepancies in the beneficiary selection process.
- 3) Mechanism should be developed for the true participation of beneficiaries at all stages of project management and it should include selection of sites, nursery raising, selection of tree species; thinning, pruning and felling of trees, marketing of forest produce and ensuring beneficiaries' participation in the benefit sharing process.
- 4) There should be more adaptive and flexible approaches rather than single plan in case of implementation of SF projects. Successful SF practice in a particular area requires consideration of local environmental and socio-economic conditions of people. These factors need to be pursued through different strategies rather than single blue print approach.
- 5) Selection and preference of species are a function of class and gender. Local knowledge and knowledge of women about tree species should be incorporated in the Social Forestry projects.
- 6) Steps should also be taken for the true participation of women in the Social Forestry projects.
- 7) Short rotation plant species/intermediate crops should be planted along with long rotation plants for the continuous supply of forest produce.

6.3 Recommendations for Further Research

- 1) Research is needed on silvicultural management of mixed species and species-site matching.
- 2) Studies are needed to find out the quality and quantity of organic matter added to the soil by different plantation species.
- 3) Research is also needed on relative canopy light transmittance of different plantation species and its impacts on understorey biodiversity.
- 4) There is a general lack of base line data on the impact of Social Forestry on actual poverty alleviation in Bangladesh. Primary research is needed on the socio-economic conditions of aspiring beneficiaries prior to Social Forestry intervention to address the gap.
- 5) Investigation is needed on the indirect, non-economic benefits and opportunity cost of Social Forestry in order to provide a more complete picture of how Social Forestry may contribute to poverty alleviation.
- 6) Future research programmes should attempt to develop an effective mechanism for bottom up participation in Social Forestry
- 7) Research is needed on gender role and productivity of Social Forestry.

References

REFERENCES

- Abbasi, S.A. and Vinithan, S. (1997). Ecological Impacts of Eucalypts-myths and realities. *Indian Forester*, 123, 710-739.
- Abedin, Z., Akter, S. Hoque, F. and Alam, S. (1988). Uses of Multipurpose Trees on the Small Farms of the Low Rainfall Ganges Floodplain Soils of Bangladesh. In *Multipurpose Tree Species For Small Farm Use*. D. Withington, K.G. McDicken, C.B Sastry and N.R. Adams (Eds.) Winrock International Institute for Agricultural Development Centre of Canada.
- Ahamed K. M. (2003). Barind Tract. In S. Islam (Ed.), *Banglapedia* (Vol. 2, pp. 69-71). Dhaka: Asiatic Society of Bangladesh.
- Ahamed, A. U., Siddiqi, N.A, Choudhuri, R.A. (1999). Vulnerability of Forest Ecosystems of Bangladesh to Climate Change. In S. Huq, Z. Karim, M. Asaduzzaman and F. Mahtab (Eds.), *Vulnerability of Forest Ecosystems of Bangladesh to Climate change* (pp. 93-111). Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Ali, H.M. (1996). Problems and Prospects of Social Forestry in Madhupur Forest Zone of Bangladesh. *Bangladesh Journal of Training & Development*, 9(2), 27-32.
- Ali, S. S. (2003). Forests and Forestry. In S. Islam (Ed.), *Banglapedia* (Vol. 4, pp. 248-250). Dhaka: Asiatic Society of Bangladesh.
- Arnold, J.E.M. (1992). *Community forestry: Ten years in review. Community Forestry Note 7*. FAO: Rome. Retrieved March 3, 2004 from http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/u5610e/u5610e00.htm.

- Asia Pacific Forestry Commission (1998) *Asia Pacific Forestry Sector Outlook Study. Country report, Bangladesh, Working Paper no-APFSOS/WP/48*, Bangkok: Asia pacific forestry commission. Retrieved February 19, 2005, from http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/003/Y0165E/Y0165E00.HTM .
- Bangladesh National Herbarium. (2001). *Floral Survey of Bangladesh*. Dhaka: Bangladesh National Herbarium.
- Bangladesh Planning Commission (1995). *Participatory Perspective Plan for Bangladesh: 1995- 2010*. Dhaka: Planning Commission, Ministry of Planning, GOB.
- BARC. (1991). *Bhumi O Mitrika Sampad Babohar Nirdeshika, Godagari thana* . Dhaka: Bangladesh Agricultural Research Council.
- BARC. (1997). *Bhumi O Mitrika Sampad Babohar Nirdeshika, Nachol thana* . Dhaka: Bangladesh Agricultural Research Council.
- BARC. (1998). *Bhumi O Mitrika Sampad Babohar Nirdeshika, Niamotpur thana* . Dhaka: Bangladesh Agricultural Research Council.
- BBS. (1990). *Statistical Year Books of Bangladesh 1990*. Dhaka: Bangladesh Bureau of Statistics.
- BBS. (1993). *Bangladesh Population Census 1991, National series, Vol. 2, Unions Statistics*. Dhaka: Bangladesh Bureau of Statistics.
- BBS. (2000a). *Census of Agriculture 1996, Zila series: Rajshahi*. Dhaka: BBS.
- BBS. (2000b). *Census of Agriculture 1996, Zila series: Nawabganj*. Dhaka: Bangladesh Bureau of Statistics
- BBS. (2000c). *Census of Agriculture 1996, Zila series: Naogaon*. Dhaka: Bangladesh Bureau of Statistics.

- BBS. (2001a). *Statistical Year Books of Bangladesh 2001*. Dhaka: Bangladesh Bureau of Statistics.
- BBS. (2001b). *Monthly Statistical Bulletin Bangladesh, November 2001*. Dhaka: Bangladesh Bureau of Statistics.
- BBS. (2002). *Statistical Year Books of Bangladesh 2002*. Dhaka: Bangladesh Bureau of Statistics.
- BBS. (2003). *Population Census 2001, National Report (Provisional)*. Dhaka: Bangladesh Bureau Statistics.
- BBS. (2004). *Statistical Year Book of Bangladesh 2002*. Dhaka: Bangladesh Bureau of Statistics.
- BFD. (2003). *Participatory Forestry Newsletter. Forest Department, Bulletin No. 1, May, 2003*. Dhaka: BFD.
- BFD. (n.d). *Social Forestry*. Retrieved April 24, 2004 from www.bforest.gov.bd.
- BMDA. (2003). *Final Report on Barind Environmental Action Plan (BEAP)*. Rajshahi: Barind Multipurpose Development Authority.
- BMDA. (n. da). *Barind Tract: Its Development Activities (as on January 2003)*. Rajshahi: Barind Multipurpose Development Authority.
- BMDA. (n. db). *Progress Report for the Month of January 2003*. Barind Multipurpose Development Authority. Rajshahi: Barind Multipurpose Development Authority.
- Brammer, H. (1996). *Geography of the Soils of Bangladesh*. Dhaka: University Press Limited.
- Cairns, J. Jr. (2002). Rationale for restoration. In: M.R. Perrow and A.J. Davy (Eds.). *Handbook of Ecological Restoration: Vol. 1. Principles of Restoration* (pp. 10-23.). Cambridge: University Press, Cambridge.
- Centre for Policy Dialogue (2002). *Forestry, Forest Biodiversity & Governance: Looking for a Pro-people Policy, Report No. 50*, Dhaka, Bangladesh: Centre for Policy Dialogue.

- Choudhury, J.K. (2003). *National Forest Policy Review, Bangladesh*. Retrieved October 27, 2004 from http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/005/AC921E/AC921E00.HTM.
- Chowdhury, A.M. (2003). Varendra. In S. Islam (Ed.), *Banglapedia* (Vol. 10, p. 298). Dhaka: Asiatic Society of Bangladesh.
- Chowdhury, S.A. (2004). Participation in Forestry: A Study of People's Participation on the Social Forestry Policy in Bangladesh: Myth and Reality? Unpublished M. Phil thesis. University of Bergen, Norway.
- Cuevas, E. and Lugo, A.E. (1998). Dynamics of organic matter and nutrient return from litterfall in stands of ten tropical tree plantation species. *Forest Ecology and Management*, 112(3), 263-279.
- Davidson, J. (2000). *Consultancy Report on Social Forestry*. Chittagong, Bangladesh: Bangladesh Forest Research Institute.
- Dey, T. K. (1996). *Samajik Bonayon*. Comilla: Anubha Dey, Dey Kutir, Tolagram, Barura.
- Divan, S. and Roseneranz, A. (2001). *Environmental Law and Policy in India*. (2nd ed.). New Delhi: Oxford University Press.
- Drechsel, P.; Glaser, B.; Zech, W. (1991). Effect of four multipurpose tree species on soil amelioration during tree fellow in Central Togo. *Agroforestry Systems*, 16(3), 193-202.
- Duguma, B.J.; Tonye, J. (1994). Screening of Multipurpose tree and shrub species for agroforestry in the humid low lands of Cameron. *Forest and Management*. 64, 2-3.
- Environmental Justice Foundation. (2004). *Farming The Sea, Costing The Earth: Why we Must Green The Blue Revolution*. Retrieved October 27, 2004 from <http://www.ejfoundation.org/reports>.

- Farley, K.A., and Kelly, E.F.(2004). Effects of afforestation of a paramo grassland on soil nutrient status. *Forest Ecology and Management*, 195, 281-290.
- FAO. (1978). *Forestry for Local Community Development*, Forestry paper 7. Rome: Food and Agriculture Organization. Retrieved September 11, 2004 from http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/t0692e/t0692e00.htm.
- FAO. (2000). *FRA 2000, Forest Resources of Bangladesh, Country Report, Working paper 15*. Rome: Food and Agriculture Organization.
- FAO. (2003). *State of world's Forest 2003*. Rome: Food and Agriculture Organization. Retrieved September 29, 2003 from <http://www.fao.org/forestry/foris/webview/forestry2/index.jsp?siteId=3321&sitetreeId=10107&langId=1&geoId=0>.
- Farooque, M. (1997). *Forests in Bangladesh: Issues and Remedies*. Dhaka: Environmental Lawyers Association (BELA).
- Friends of Earth-Bangladesh.(2003). Global Warming and Monoculture Plantations: A Double Menace to Bangladesh. In *Tree trouble A Compilation of Testimonies on the Negative Impact of Large-scale Monoculture Tree Plantations prepared for the sixth Conference of the Parties of the Framework Convention on Climate Change*. Retrieved December 11, 2003 from <http://www.wrm.org.uy/actors/CCC/trouble6.html#2>.
- Gafur, M.A., Karim, A., and Khan M.A.A. (1978). Phytosociological studies of hills of Chittagong University Campus, *Chittagong University Studies*. Vol. 3 (II), 11-28.
- Gain, P. (1998a). *The Last Forests of Bangladesh*. Dhaka: Society for Environment and Human Development (SHED).
- Gain, P. (1998b). (Eds.) Shrimp for Export-Symbol of Destruction. In *Bangladesh, Environment Facing the 21st Century* (pp) Dhaka: Society for Environment and Human Development (SEHD).

- Geldenhuys, C.J. (1997). Native forest regeneration in pine and eucalypt plantations in Northern Province, South Africa. *Forest Ecology and Management*. 99, 101-115.
- GOB. (2000, April 10). *The Bangladesh Gazette, Additional copy*, 1330-1331.
- Gupta, P.K. (2000). *Methods in Environmental Analysis Water, Soil and Air*. Jodhpur, India: AGROBIOS(INDIA).
- Harrington, R.A. and Ewel J.J. (1997). Invasibility of tree plantations by native and non-indigenous plant species in Hawaii. *Forest Ecology and Management*, 99,153-162.
- Hobley, M.E. (1990). *Social reality, Social forestry: the case of the two Nepalese panchayats*. PhD thesis, Canberra, Australian National University.
- Hossain, J. (2003). Agroforestry Sector Review. Dhaka: Inter cooperation.
- Hossain, M. (2004). Synecological studies on the undergrowth flora in some socially afforested areas. Unpublished PhD thesis. University of Rajshahi, Rajshahi.
- Hossain, S. (2000). *Participatory Forest Management in Bangladesh, Bangladesh*. POUSH. Retrieved January 24, 2004 from <http://www.iges.jp/en/fc/phase1/2ws-3-bangla.pdf>.
- Hunter, W.W. (1876). *A Statistical Accounts of Bengal. Vol. VIII. Districts of Rajshahi and Bogra*. New Delhi: D.K. Publishing House.
- Huq, F.M. and Alim, A. (1995). *Social Forestry in Bangladesh*. Dhaka: BRAC-Winrock International.
- Isik, K.; Yaltirik. F.; and Akesen A. (1997). *The interrelationship of Forests, biological diversity and the maintenance of the natural heritage*. Retrieved September 10, 2003 from <http://www.fao.org/docrep/w6251E/w6251e05.htm>.
- Islam, M.A (2005). Bangladesher Artho-Samjik Samriddhi Arjoney Brikhoropon O Bonobhibag. In *National Tree Plantation Souvenir 2005*. Dhaka: Bangladesh Forest Department.

- Islam, M.A., Rahman, M.M, Hossain, A.B.M.E, Hoque, S. (2001). Physico-chemical properties of Jahangirnagar University campus and their impacts on existing phytodiversity. *Bangladesh J. Life Sci.*, 13(1&2), 75-81.
- Islam, N. (1997). 'Watershed Management Activities under Brendra Integrated Development Programme' In *Participatory Approaches to Integrated Watershed Management in Bangladesh*, Proceedings of the national workshop held at Bangladesh Forest Academy, 1-5 July, Chittagong, Bangladesh. \
- Kaisaruzzaman, A. K. M. (2003). Godagari Upazila. In S. Islam (Ed.), *Banglapedia* (Vol. 4, pp. 418-419). Dhaka: Asiatic Society of Bangladesh.
- Kamruzzaman, M. (2005). Impact of Urbanization and Industrialization on the Natural Plant Communities. Unpublished Ph.D. thesis, University of Rajshahi, Rajshahi.
- Karim, Z. and Iqbal, A. eds. (2001). *Impact of Land Degradation in Bangladesh- Changing Scenario in Agricultural Land Use*. Dhaka: Bangladesh Agricultural Research Council.
- Khan, M.S. (2002). Barind: Environment and Conservation. In *Souvenir, Annual Bangladesh Botanical Conference-2001*. Rajshahi, Bangladesh: Department of Botany, Rajshahi University and Bangladesh Botanical Society.
- Khan, N. A. (2001a). *Regional Study on Institutional Reform, Final Report on Bangladesh Case study*. Manila: Asian Development Bank.
- Khan, N. A. (2001b). *Social Forestry Versus Social Reality: Patronage and Community Based Forestry in Bangladesh*. London: International Institute for Environment and Development.
- Khan, N.A. and Begum, S.A (1997). Participation in Social Forestry re-examined a case study from Bangladesh. *Development in Practice*, 7 (3), 260-266.

- Khanduri, V.P., Baduni, N.P, and Sharma, C.M. (1997). Community Structure and Composition in the Moist Deciduous Miscellaneous and Riverian Khair-Sissu Forests of Himalayan Foot Hills. *Bangladesh Journal of Forest Science*, 26(2), 65-68.
- Larsen, J. (2003, March). Forest cover shrinking. *Earth time*, Retrieved September 8, 2003 from <http://www.sdearthtimes.com/et0203/et0203s10.html>.
- Lugo, A.E. (1992). Tree plantation for rehabilitating damaged lands in the tropics. In M.K. Wali,(Eds) *Environmental Rehabilitation*(pp. 247-255). Vol. 2. The Hague: SPB Academic Publishing.
- Mahtab F.U.; Ishaque, M.; Ahamed, N.; and Sharif, M.R. (1984). *Evaluation of Community Forestry Project-1 for FAO, ADB, and GOB (Draft report)*. Dhaka: Bangladesh: Prokaushal Sangsad Ltd.
- Michael, P. (1984). *Ecological Methods for Field and Laboratory Investigations*. New Delhi: Tata McGraw-Hill Publishing Company Ltd.
- Ministry of Finance (2004). *Bangladesh Arthonoitik Samiksha 2004*. Dhaka: Ministry of Finance.
- MOEF. (1993). *Forestry Master Plan, Statistical data*. Dhaka: Ministry of Environment and Forests, GOB, Asian Development Bank (TA No 1355- BAN).
- MOEF. (1997). *The Bangladesh National Conservation Strategy*. Dhaka: Ministry of Environment and Forests, GOB.
- MOEF. (2000). *Preliminary National Report on the UNCCD Implementation for COP4*. Dhaka: Ministry of Environment and Forests, Government of Bangladesh. Retrieved October 5, 2004 from <http://www.gm-unccd.org/FIELD/Countries/Bangl/ban-eng00.pdf>.
- MOEF. (2002). *Second National Report on Implementation of United Nations Convention to Combat Desertification, Final Draft, Ministry of Environment and Forests government of Bangladesh*. Retrieved September 3, 2004 from <http://www.unccd.int/cop/reports/asia/national/2002/bangladesh-eng.pdf>.

- Montagnini, F. (2001). Strategies for the recovery of degraded ecosystems: experiences from Latin America. *Interciencia*, 26, 498–503.
- Mridha, M. N. (2002). Growth of Some Selected Social forest species and extension of social forestry in Bangladesh. Unpublished Ph.D. thesis. Institute of Biological Science, University of Rajshahi, Rajshahi, Bangladesh.
- Mustafa M. M. (1997). Gender Roles in Homegarden Management in Bangladesh. *Chittagong University studies, Part II: Science*, 21(2), 79-83.
- Mustafa M. M. (2002). A Review of Forest Policy Trends in Bangladesh. *Policy Trend Report*, 114-121. Retrieved September 16, 2004 from <http://www.iges.or.jp/en/fc/pdf/report5/PTR0208.pdf>
- Odum, E. P. (1971). *Fundamentals of Ecology*. 3d ed. Philadelphia: Saunders College Publishing.
- Oosting, J.H. (1956). *The Study of Plant communities*. 2nd ed. Sanfransisco: W.H. Freeman and Company.
- Otsamo, R. (2000). Secondary forest regeneration under fast growing forest plantations on degraded *Imperata cylindrica* grasslands. *New Forests*, 19, 69-93.
- Parrotta, J.A. (1992). The role of plantation forests in rehabilitating degraded tropical ecosystems. *Agriculture Ecosystem & Environment*, 41, 115-133.
- Parrotta, J.A. (1995). Influence of overstory composition on understory colonisation by native species in plantations on a degraded tropical site. *Journal of Vegetation Science*, 6, 627-636.
- Pasha, M. K. (2003). Forest Industries Development Corporation. In S. Islam (Ed.), *Banglapedia* (Vol. 4, pp. 263-264). Dhaka: Asiatic Society of Bangladesh.
- Petersen, L. (2002). *Analytical Methods*. Dhaka: Soil Resources Management Development Institute.

- Poore, M.E.D. and Fries, C. (1985). *The ecological effect of Eucalyptus*. F.A.O. Forestry Paper 59. Rome: FAO.
- Puri, G. S. (1960). *Indian Forest Ecology*. Vol. I&II. New Delhi: Oxford Book and Stationary Co.
- Rahman, A. (2000). Plantation Campaign: Boon or Bane for Biodiversity? In Q.I Chowdhury (Eds.) *Bangladesh State of Biodiversity*, (pp.115-116). Dhaka: Forum of Environmental Journalist of Bangladesh.
- Rahman A. A., Mallick. D.L., Haque, N., Nisat, A. (2002). *Trends in Natural Resource Management in Bangladesh: Looking for Integration and New Institutional Framework*. Dhaka: Bangladesh Centre for Advanced Studies.
- Rahman. M. (2003a). Niamotpur Upazila. In S. Islam (Ed.), *Banglapedia* (Vol. 7, pp. 301-302). Dhaka: Asiatic Society of Bangladesh.
- Rahman, M.S, Ahamed, N.V., and Sajjad, S.A. (1980). Ecological survey of degraded wood lands in Rajshahi Universtiy Campus, *Proceedings of the fourth Annual Bangladesh Science Conference*, II, 4-5.
- Rahman, S. (2003b). *Udbid Poribeshtotto O' Udbid Bhugole* (Plant Ecology and Phytogeography). Dhaka: Anannya
- Rahman, S. (2005). *Poribeshbiggun O Jibbhugol* (Environmental Science and Biogeography). Dhaka: Abosar.
- Ramvos, B.V and Roberts, M.R. (2000). *Fundy Model Forest Final Report*. New Brunswick: Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton.
- Rasheed, K.B.S. (2003, August 01). Containing Land Degradation and Desertification. *The Daily Star*.
- Rocheleau, D., Webber, F. and Field, J.A. (1988). *Agroforestry in Dryland Africa*. Nairobi: ICRAF.

- Roy, D. and Halim, S. (2001, June 2). State versus People: The Forest Laws of 2000. *The Daily Star*.
- Roy, M. K. (2000). The Process of Development of the Forestry Sector of Bangladesh in *National Tree Planting Campaign and Brikhamela (Tree fair) Souvenir, 2000*. Dhaka: Bangladesh Forest Directorate, Bono Bhaban.
- Salehuddin, A.B.M. and Rubugio, L.L. (1988). Social Forestry in Bangladesh. In *Proceedings of national workshop of "Homestead plantation and agroforestry in Bangladesh: held on July 17-19, 1988, Joydebpur, Gazipur, Bangladesh*.
- Siddique, A. (Eds.) (1976). *Bangladesh District Gazetteers, Rajshahi*. Dhaka: GOB.
- Silva, C.S. (1973). An evaluation of the nutrient status of the Rubber soils of Ceylon. *J. Rubb. Res. Ins. Ceylon.*, 48(3 &4), 147-59.
- Sing, E. (1979). Floristic composition & life-forms of the sand dune herbaceous vegetation at Narhar near Pilani, Rajasthan, India. *Indian Journal of Ecology*, 6(1), 9-19.
- Steven, P.R. (1987). *A simplified field manual for site classification and site suitability assessment in Bangladesh forests*. Assistance to the second agricultural research project, Bangladesh. FAO Working Paper No.1. FAO.
- Struhsaker, T.T. (1987). Forestry issues and conservation in Uganda. *Biological Conservation*, 39, 209-234.
- Sukla, R. S and Chandel, P.S. (2000). *Plant Ecology and Soil Science*. New Delhi: S. Chand & Company Ltd.
- Taru. M. I. (2003). Nachol Upazila. In S. Islam (Ed.), *Banglapedia* (Vol. 7, pp. 190-191). Dhaka: Asiatic Society of Bangladesh.
- The Independent (2002, 20 December). Killer disease attacks Sissoo (*Dalbergia sissoo Roxb.*) trees. *The Independent*.

- Torquebiau, E. (Eds.). (1991). *Agroforestry Research Planning for the High Barind tract, Rajshahi, Bangladesh-Report of a Diagnostic and Design Survey*. Dhaka: Bangladesh Agricultural Research Council.
- Uddin, M.J., Hussain, M.S., Rahman, M.M., Mazumder, A.R., Rashid M.H. (2000). Social Forestry potentials of the degraded Sal (*Shorea robusta*) forests in Chandra area of Madhupur Tract. *Bangladesh J. Sci. & Tech.*, 2(1), 41-50.
- UNFPA (2005). *State of World Population 2004*. Retrieved July 19, 2005 from <http://www.unfpa.org/publications/detail.cfm?ID=197&filterListType=1>.
- UNO (2002). *Johannesburg Summit 2002, Bangladesh Country Profile*. Retrieved October 5, 2004 from http://www.bdix.net/sdnbd_org/world_env_day/2002/wssd/wssd&bangladesh/bangladesh.pdf
- Vivrette, N.J. and Muller, C.H. (1977). Mechanism of invasion and dominance of coastal grassland by *Mesembryanthemum crystallinum*. *Ecological Monographs*, 47, 301-318.
- Zubel, J. B., Greet, WYK.V, and Stahl, P. (1987). *Growing exotic forest*, A Wiley-Interscience Publication. New York, USA, PP-9.
- Zuberi, M. I. (1998). Role of Non-Forest area in Wood Fuel Production: North-West Bangladesh. In *Wood Fuel in Bangladesh –Production and Marketing - Technical papers from the National Training Course RADA, Bogra, Bangladesh, Decmber 7-11 1996* by the FAO, 151-170. Bangkok, Thailand: Food and Agriculture Organization, MOEF, GOB.

Appendices

APPENDICES

Appendix A: Forest Areas of Bangladesh by Different Years

Year	% of Total Area	Year	% of Total Area
1971-72	16.50	1984-85	14.38
1972-73	16.53	1985-86	15.68
1973-74	15.36	1986-87	13.40
1974-75	15.38	1987-88	13.45
1975-76	15.48	1988-89	12.53
1976-77	16.70	1989-90	12.60
1977-78	16.71	1990-91	12.81
1978-79	16.73	1991-92	13.08
1979-80	17.28	1992-93	13.16
1980-81	17.22	1993-94	13.16
1981-82	17.35	1994-95	13.60
1982-83	13.67	1995-96	13.60
1983-84	13.83	2001	13.36

Sources: BBS (1990); BBS (2001b); BBS (2002)

Appendix B: Precipitation Data of Three BWDB Observation Stations in the Study Area

Year	Godagari mm	Nachol mm	Manda mm
1980	1435.10	1558.58	1612.64
1981	1567.68	1812.58	1214.37
1982	986.02	796.29	1011.68
1983	1256.28	1328.42	1573.53
1984	1318.00	1329.69	1704.08
1985	1375.66	1343.66	1110.99
1986	1661.92	1729.99	1415.79
1986	1697.48	1558.79	1977.13
1987	2182.00	1849.50	1613.20
1988	1094.60	1279.30	1243.00
1989	1277.00	1564.20	1360.50
1990	1515.20	1572.20	1847.20
1991	973.30	1342.30	1331.70
1993	1536.40	1495.10	1191.50
1994	1530.50	849.30	1074.10
1995	1448.30	1515.60	1504.10
1996	1240.00	1112.50	1290.00
1997	1227.00	1135.20	1158.00
1998	1386.20	1716.80	1590.00
1999	1634.70	2568.90	1476.20
2000	1612.90	2084.50	1731.90
2001	1477.30	1568.50	1762.10
2002	1153.10	1526.10	1863.40
Average	1416±55.45	1506±79.32	1463.35±57.67

Source: Bangladesh Water Development Board, Rajshahi.

Appendix C: Afforestation by Bangladesh Forest Department and BMDA in the Study Area

Appendix C-1: Afforestation by Bangladesh Forest Department

Project	Year	Godagari		Nachol			Niamotpur		
		SP	No. of Bene.	SP	WL	No. of Bene.	SP	WL	No. of Bene.
		Km/Mile		Km/Mile	Ha		Km	Ha/Acre	
CFDP	83-84	1 Mile	5	-	-	-	7 Mile	-	35
CFDP	84-85	8 Mile	73				10 Mile	-	50
CFDP	85-86	22 Mile	107				14 Mile	-	70
CFDP	86-87	3 Mile	15						
TANDP	87-88	-	-	-	-	-	-	10 acre	-
Revenue	90-91	-	-	3.2 Km	-	15			
TANDP	-	-	-	-	-	-	-	70 acre	-
TANDP	92-93	-	-	7 Km	-	25			
TANDP	93-94	7 Km	35	2 Km	-	10	3 Km	-	15
TANDP	94-95	28 Km	140	3 Km	-	15	3 Km	-	15
FESP	95-96	5 Km	25	3 Km	-	15	3 Km	-	15
FESP	96-97	3 Km	15	3 Km	-	15	9 Km	20 ha	45
Revenue	97-98						5 Km	-	25
Revenue	98-99	3 Km	15	-	-	-	3 Km	-	15
FSP	2000-01	3 Km	15	6 Km	-	30	2 Km	-	10
FSP	2001-02	21 Km	105	19 Km	95 ha		10 Km	-	50

Source: Abu Naser Khan, DFO, Rajshahi Social Forest Division, (Personal communication, January 2004.)

SP: Strip plantation, CFDP: Community Forestry Development Project, TANDP: Thana Afforestation and Nursery Development Project, FESP: Forestry Extension Services Project, FSP: Forestry Sector Project.

Appendix C-2: Afforestation by BMDA

Project	Year	Godagari	Nachol	Niamotpur	Total
1 st phase BIDAP	1985-1990	17648	239270	186449	443367
2 nd phase BIDAP	91-92 to 2001-02	436891	378297	219046	1034234
IAP	97-98 to 2001-02	74103	89922	113073	277098
Total		528642	707489	518568	1754699

Source: BMDA (n. db)

BIDAP: Barind Integrated Area Development Project, IAP: Intensive Afforestation Project

Appendix D: Results of t-Test Comparing Differences in Soil Attributes of PSs and NPSs of Three Sites

Parameter	Site	Year	Unit	Planted Soil	Non Planted Soil	t Stat	P(T<=t) two-tail	t Critical two-tail
pH	A	Y1		6.50	6.10	-0.285	0.787	2.571
		Y2		6.94	7.05			
	B	Y1		4.75	5.00			
		Y2		4.90	5.45			
	C	Y1		6.50	6.25			
		Y2		6.52	6.50			
OM	A	Y1	%	2.30	1.45	2.513	0.054	2.571
		Y2		1.20	1.16			
	B	Y1		2.38	2.02			
		Y2		1.84	1.84			
	C	Y1		2.90	1.50			
		Y2		3.13	1.50			
K	A	Y1	meq/100gm soil	0.32	0.22	2.887*	0.034	2.571
		Y2		0.50	0.24			
	B	Y1		0.35	0.12			
		Y2		0.37	0.14			
	C	Y1		0.20	0.29			
		Y2		0.40	0.19			
Ca	A	Y1	meq/100gm soil	5.50	5.20	-0.061	0.954	2.571
		Y2		4.50	4.40			
	B	Y1		3.30	4.80			
		Y2		1.90	4.40			
	C	Y1		7.80	4.40			
		Y2		4.70	4.80			
Mg	A	Y1	meq/100gm soil	1.90	3.20	0.453	0.670	2.571
		Y2		2.00	2.20			
	B	Y1		2.10	1.20			
		Y2		1.30	1.10			
	C	Y1		2.30	1.70			
		Y2		1.60	0.90			
Total N	A	Y1	%	0.12	0.08	2.782*	0.039	2.571
		Y2		0.10	0.06			
	B	Y1		0.12	0.11			
		Y2		0.09	0.09			
	C	Y1		0.14	0.09			
		Y2		0.15	0.05			

Appendix D continued

Parameter	Site	Year	Unit	Planted Soil	Non Planted Soil	t Stat	P(T<=t) two-tail	t Critical two-tail
P	A	Y1	μ gm/gm soil	4.42	3.93	-0.265	0.802	2.571
		Y2		6.24	3.57			
	B	Y1		3.25	2.12			
		Y2		4.01	11.60			
	C	Y1		2.18	2.13			
		Y2		5.35	4.46			
S	A	Y1		6.21	7.02	-1.010	0.359	2.571
		Y2		16.69	15.60			
	B	Y1		4.35	10.48			
		Y2		20.52	15.87			
	C	Y1		5.47	7.71			
		Y2		6.58	14.78			
B	A	Y1		0.37	0.31	1.758	0.139	2.571
		Y2		0.34	0.30			
	B	Y1		0.30	0.29			
		Y2		0.19	0.23			
	C	Y1		0.43	0.18			
		Y2		0.57	0.19			
Cu	A	Y1		1.24	2.70	-5.529*	0.003	2.571
		Y2		1.20	2.00			
	B	Y1		2.00	4.46			
		Y2		1.80	2.80			
	C	Y1		1.22	2.42			
		Y2		0.90	2.00			
Fe	A	Y1		51.00	140.00	-0.363	0.732	2.571
		Y2		25.00	40.00			
	B	Y1		201.00	261.00			
		Y2		100.00	40.00			
	C	Y1		85.00	100.00			
		Y2		120.00	56.00			
Mn	A	Y1		40.00	40.00	2.419	0.060	2.571
		Y2		30.00	17.00			
	B	Y1		70.00	16.00			
		Y2		64.00	17.00			
	C	Y1		40.00	20.40			
		Y2		10.00	8.00			
Zn	A	Y1		1.26	0.96	2.052	0.095	2.571
		Y2		1.30	1.20			
	B	Y1		1.20	0.72			
		Y2		0.40	0.70			
	C	Y1		1.70	0.72			
		Y2		1.40	0.66			

* Significant at 5% level

**Appendix E: List of Plant Species as Recorded in Three Sites during Study Period
(July 2003-June 2005)**

Sl.no	Botanical Name	Family	Category	Comments
1	<i>Vitis trifolia</i> (L.) Don	Vitaceae	Climber	
1	<i>Achyranthes aspera</i> L.	Amaranthaceae	Herb	
2	<i>Alysicarpus vaginalis</i> DC.	Papilionaceae	Herb	
3	<i>Amaranthus spinosus</i> L.	Amaranthaceae	Herb	
4	<i>Amaranthus viridis</i> L.	Amaranthaceae	Herb	
5	<i>Brachiaria distachya</i> (L.) Stapf.	Gramineae	Herb	
6	<i>Brachiaria</i> sp	Gramineae	Herb	C
7	<i>Centella asiatica</i> (L) Urban.	Umbelliferae	Herb	
8	<i>Croton bonplandianum</i> Bail.	Euphorbiaceae	Herb	C
9	<i>Cynodon dactylon</i> Pers.	Gramineae	Herb	
10	<i>Cyperus kyllinga</i> Endl.	Cyperaceae	Herb	
11	<i>Cyperus rotundus</i> L.	Cyperaceae	Herb	
12	<i>Desmodium triflorum</i> (L.) DC.	Papilionaceae	Herb	C
13	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	Gramineae	Herb	
14	<i>Digitaria granularis</i> (Trin.) Henr.	Gramineae	Herb	
15	<i>Digitaria sanguinalis</i> (L.) Scop.	Gramineae	Herb	
16	<i>Echinochloa colonum</i> (L.) Link.	Gramineae	Herb	
17	<i>Eleusine compressa</i> (Forsk.) Ash. & Schweinf.	Gramineae	Herb	
18	<i>Eleusine indica</i> (L.) Gaertn.	Gramineae	Herb	C
19	<i>Eragrostis tenella</i> (L.) P. Baeuv.	Gramineae	Herb	
20	<i>Eragrostis unioides</i> (Retz.) Nees.	Gramineae	Herb	
21	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Herb	
22	<i>Evolvulus nummularius</i> L.	Convolvulaceae	Herb	C
23	<i>Hemigraphis hirta</i> T. Anders.	Acanthaceae	Herb	
24	<i>Ichnanthus vicinus</i> (Bail) Merr.	Gramineae	Herb	C
25	<i>Imperata cylindrica</i> (L.) P. Beauv.	Gramineae	Herb	
26	<i>Isachne miliacea</i> Roth.	Gramineae	Herb	
27	<i>Leucas aspera</i> (Willd.) Link.	Labiatae	Herb	
28	<i>Lippia nodiflora</i> (L.) Rich.	Verbenaceae	Herb	
29	<i>Mimosa pudica</i> L.	Mimosae	Herb	
30	<i>Nelsonia campestris</i> R. Br.	Acanthaceae	Herb	
31	<i>Ocimum basilicum</i> L.	Labiatae	Herb	
32	<i>Oplismenus compositus</i> (L.) P. Beauv.	Gramineae	Herb	C
33	<i>Oxalis corniculata</i> L.	Oxalidaceae	Herb	
34	<i>Paspalidium flavidum</i> (Retz.) A. Camus.	Gramineae	Herb	
35	<i>Phyllanthus niruri</i> L.	Euphorbiaceae	Herb	
36	<i>Saccharum spontaneum</i> L.	Gramineae	Herb	
37	<i>Sida acuta</i> Burm.	Malvaceae	Herb	
38	<i>Sida cordifolia</i> L.	Malvaceae	Herb	C
39	<i>Solanum nigrum</i> L.	Solanaceae	Herb	
40	<i>Sporobolus diander</i> (Retz.) P. Beauv.	Gramineae	Herb	
41	<i>Vetiveria zizanioides</i> (L.) Nash	Gramineae	Herb	

Appendix E continued

Sl. no	Botanical Name	Family	Category	Comments
1	<i>Calotropis procera</i> Br.	Asclepiadaceae	Shrub	
2	<i>Cassia sophera</i> L.	Caesalpineae	Shrub	
3	<i>Clerodendrum viscosum</i> Vent.	Verbenaceae	Shrub	
4	<i>Flacourtia indica</i> (Brum. f.) Merr.	Flacourtiaceae	Shrub	
5	<i>Glycosmis pentaphylla</i> (Retz.) A. DC.	Rutaceae	Shrub	
6	<i>Lantana camara</i> L. Var.	Verbenaceae	Shrub	
1	<i>Acacia auriculiformis</i> A. cunn. ex Benth.	Caesalpineae	Tree seedling	C
2	<i>Acacia nilotica</i> L. Del.	Caesalpineae	Tree seedling	
3	<i>Azadirachta indica</i> A. Juss.	Meliaceae	Tree seedling	
4	<i>Dalbergia sissoo</i> Roxb.	Papilionaseae	Tree seedling	
5	<i>Phoenix sylvestris</i> (L.) Roxb.	Palme	Tree seedling	
6	<i>Psidium guajava</i> (L.) Bat.	Myrtaceae	Tree seedling	
7	<i>Syzygium cumini</i> (L.) Skeel.	Myrtaceae	Tree seedling	
8	<i>Terminalia arjuna</i> (Roxb.) Wt. & Arn	Combretaceae	Tree seedling	
9	<i>Zizyphus mauritiana</i> Lamk.	Rhamnaceae	Tree seedling	

C = Species common in the three sites

Appendix F: Phytodiversity of Site A during Study Period (July 2003 to June 2005)

(Data means of 30 replications)

Sl. No.	Species recorded	ANIP	ni/N	$D=(ni/N)^2$	H	E
1	<i>Acacia nilotica</i> L. Del (Seedling)	0.17	0.00016	0.00000003	0.0014	
2	<i>Achyranthes aspera</i> L.	106.83	0.10470	0.01096307	0.2363	
3	<i>Alysicarpus vaginalis</i> DC.	1.67	0.00163	0.00000267	0.0105	
4	<i>Amaranthus spinosus</i> L.	2.17	0.00212	0.00000451	0.0131	
5	<i>Azadirachta indica</i> A. Juss. (Seedling)	3.17	0.00310	0.00000963	0.0179	
6	<i>Brachiaria sp</i>	304.83	0.29876	0.08925727	0.3609	
7	<i>Croton bonplandianum</i> Bail.	34.33	0.03365	0.00113227	0.1141	
8	<i>Cynodon dactylon</i> Pers.	46.33	0.04541	0.00206208	0.1404	
9	<i>Dalbergia sissoo</i> Roxb. (Seedling)	3.00	0.00294	0.00000864	0.0171	
10	<i>Desmodium triflorum</i> (L.) DC.	5.17	0.00506	0.00002564	0.0268	
11	<i>Digitaria sanguinalis</i> (L.) Scop.	39.83	0.03904	0.00152409	0.1266	
12	<i>Echinochloa colonum</i> (L.) Link.	0.17	0.00016	0.00000003	0.0014	
13	<i>Eleusine indica</i> (L.) Gaertn.	12.83	0.01258	0.00015820	0.0550	
14	<i>Eragrostis tenella</i> (L.) P. Baeuv.	2.67	0.00261	0.00000683	0.0155	
15	<i>Eragrostis unioides</i> (Retz.) Nees.	8.17	0.00800	0.00006406	0.0386	
16	<i>Evolvulus nummularius</i> L.	291.67	0.28586	0.08171321	0.3580	
17	<i>Flacourtia indica</i> (Brum. f.) Merr.	0.50	0.00049	0.00000024	0.0037	
18	<i>Ichnanthus vicinus</i> (Bail) Merr.	3.83	0.00376	0.00001411	0.0210	
19	<i>Imperata cylindrica</i> (L.) P. Beauv.	18.50	0.01813	0.00032875	0.0727	
20	<i>Oplismenus compositus</i> (L.) P. Beauv.	35.50	0.03479	0.00121053	0.1168	
21	<i>Paspalidium flavidum</i> (Retz.) A. Camus	18.33	0.01797	0.00032285	0.0722	
22	<i>Sida acuta</i> Burm.	2.83	0.00278	0.00000771	0.0163	
23	<i>Sida cordifolia</i> L.	76.50	0.07498	0.00562136	0.1942	
24	<i>Solanum nigrum</i> L.	1.00	0.00098	0.00000096	0.0068	
25	<i>Vetiveria zizanioides</i> (L.) Nash	0.17	0.00016	0.00000003	0.0014	
26	<i>Zizyphus mauritiana</i> Lamk. (Seedling)	0.17	0.00016	0.00000003	0.0014	
		1020.33	1.00	0.19	2.04	0.63

ANIP= Average Number of Individual plants, D= Index of Dominance, H= Shannon's diversity index, E= Evenness.

Appendix G: Phytodiversity of Site B during Study Period (July 2003 to June 2005)

(Data means of 30 replications)

Sl. No.	Species recorded	ANIP	ni/N	$D=(ni/N)^2$	H	E
1	<i>Acacia curculiformis</i> A. cum. ex Benth. (Seedling)	13.50	0.0116	0.00013463	0.0517	
2	<i>Alysicarpus vaginalis</i> DC.	22.00	0.0189	0.00035753	0.0750	
3	<i>Azadirachta indica</i> A. Juss. (Seedling)	0.33	0.0003	0.00000008	0.0023	
4	<i>Brachiaria</i> sp	84.33	0.0725	0.00525371	0.1902	
5	<i>Cassia sophera</i> L.	0.33	0.0003	0.00000008	0.0023	
6	<i>Centella asiatica</i> (L.) Urban.	1.33	0.0011	0.00000131	0.0078	
7	<i>Clerodendrum viscosum</i> Vent.	0.17	0.0001	0.00000002	0.0013	
8	<i>Croton bonplandianum</i> Bail.	19.83	0.0170	0.00029058	0.0694	
9	<i>Cynodon dactylon</i> Pers.	117.67	0.1011	0.01022761	0.2317	
10	<i>Cyperus rotundus</i> L.	74.50	0.0640	0.00409996	0.1760	
11	<i>Desmodium triflorum</i> (L.) DC.	12.33	0.0106	0.00011236	0.0482	
12	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	2.50	0.0021	0.00000462	0.0132	
13	<i>Eleusine indica</i> (L.) Gaertn.	78.67	0.0676	0.00457139	0.1821	
14	<i>Euphorbia hirta</i> L.	1.17	0.0010	0.00000101	0.0069	
15	<i>Evolvulus nummularius</i> L.	91.00	0.0782	0.00611716	0.1993	
16	<i>Hemigraphis hirta</i> T. Anders.	72.50	0.0623	0.00388278	0.1730	
17	<i>Ichnanthus vicinus</i> (Bail) Merr.	6.83	0.0059	0.00003449	0.0302	
18	<i>Imperata cylindrica</i> (L.) P. Beauv.	17.00	0.0146	0.00021348	0.0617	
19	<i>Isachne miliacea</i> Roth.	368.33	0.3166	0.10021882	0.3641	
20	<i>Leucas aspera</i> (Willd.) Link.	4.17	0.0036	0.00001282	0.0202	
21	<i>Mimosa pudica</i> L.	0.50	0.0004	0.00000018	0.0033	
22	<i>Nelsonia campestris</i> R. Br.	4.67	0.0040	0.00001609	0.0221	
23	<i>Ocimum basilicum</i> L.	0.50	0.0004	0.00000018	0.0033	
24	<i>Oplismenus compositus</i> (L.) P. Beauv.	137.50	0.1182	0.01396602	0.2524	
25	<i>Oxalis corniculata</i> L.	2.00	0.0017	0.00000295	0.0109	
26	<i>Phyllanthus niruri</i> L.	1.50	0.0013	0.00000166	0.0086	
27	<i>Saccharum spontaneum</i> L.	1.00	0.0009	0.00000074	0.0061	
28	<i>Sida cordifolia</i> L.	6.50	0.0056	0.00003121	0.0290	
29	<i>Sporobolus diander</i> (Retz.) P. Beauv.	20.67	0.0178	0.00031551	0.0716	
30	<i>Vitis trifolia</i> (L.) Don	0.17	0.0001	0.00000002	0.0013	
		1163.50	1.0000	0.15	2.31	0.68

ANIP= Average Number of Individual plants, D= Index of Dominance, H= Shannon's diversity index, E= Evenness.

Appendix H: Phytodiversity of Site C during Study Period (July 2003 to June 2005)

(Data means of 30 replications)

Sl. No.	Species recorded	ANIP	ni/N	(ni/N) ²	H	E
1	<i>Achyranthes aspera</i> L.	13.17	0.01358	0.0001844	0.0584	
2	<i>Amaranthus spinosus</i> L.	1.00	0.00103	0.0000011	0.0071	
3	<i>Amaranthus viridis</i> L.	2.33	0.00241	0.0000058	0.0145	
4	<i>Azadirachta indica</i> A. Juss. (Seedling)	3.50	0.00361	0.0000130	0.0203	
5	<i>Brachiaria distachya</i> (L.) Stapf.	19.67	0.02028	0.0004114	0.0791	
6	<i>Brachiaria sp</i>	44.83	0.04624	0.0021377	0.1421	
7	<i>Calotropis procera</i> Br.	2.00	0.00206	0.0000043	0.0128	
8	<i>Cassia sophera</i> L.	0.83	0.00086	0.0000007	0.0061	
9	<i>Clerodendrum viscosum</i> Vent.	6.83	0.00705	0.0000497	0.0349	
10	<i>Croton bonplandianum</i> Bail.	2.67	0.00275	0.0000076	0.0162	
11	<i>Cynodon dactylon</i> Pers.	15.33	0.01581	0.0002500	0.0656	
12	<i>Cyperus Kallinga</i> Endl.	20.83	0.02148	0.0004616	0.0825	
13	<i>Cyperus rotundus</i> L.	33.00	0.03403	0.0011582	0.1150	
14	<i>Desmodium triflorum</i> (L.) DC.	52.33	0.05397	0.0029128	0.1576	
15	<i>Dichanthium annulatum</i> (Forsk.) Stapf.	38.50	0.03970	0.0015764	0.1281	
16	<i>Digitaria granularis</i> (Trin.) Henr.	2.67	0.00275	0.0000076	0.0162	
17	<i>Digitaria sanguinalis</i> (L.) Scop.	4.17	0.00430	0.0000185	0.0234	
18	<i>Echinochloa colonum</i> (L.) Link.	29.50	0.03042	0.0009255	0.1063	
19	<i>Eleusine compressa</i> (Forssk.) Asch. & Schwenf.	10.50	0.01083	0.0001173	0.0490	
20	<i>Eleusine indica</i> (L.) Gaertn.	255.33	0.26332	0.0693373	0.3514	
21	<i>Eragrostis tenella</i> (L.) P. Baeuv.	11.83	0.01220	0.0001489	0.0538	
22	<i>Evolvulus nummularius</i> L.	190.33	0.19629	0.0385285	0.3196	
23	<i>Flacourtia indica</i> (Brum. f.) Merr.	0.17	0.00017	0.0000000	0.0015	
24	<i>Glycosmis pentaphylla</i> (Retz.) A. DC.	0.83	0.00086	0.0000007	0.0061	
25	<i>Ichnanthus vicinus</i> (Bail) Merr.	31.17	0.03214	0.0010331	0.1105	
26	<i>Lantana camara</i> L. Var.	1.17	0.00120	0.0000014	0.0081	
27	<i>Leucas aspera</i> (Willd.) Link.	5.00	0.00516	0.0000266	0.0272	
28	<i>Lippia nodiflora</i> (L.) Rich.	3.00	0.00309	0.0000096	0.0179	
29	<i>Nelsonia campestris</i> R. Br.	27.83	0.02870	0.0008239	0.1019	
30	<i>Ocimum basilicum</i> L.	6.83	0.00705	0.0000497	0.0349	
31	<i>Oplismenus compositus</i> (L.) P. Beauv.	71.67	0.07391	0.0054624	0.1925	
32	<i>Oxalis corniculata</i> L.	5.67	0.00584	0.0000342	0.0301	
33	<i>Paspalidium flavidum</i> (Retz.) A. Camus	16.17	0.01667	0.0002780	0.0683	
34	<i>Phoenix sylvestris</i> (L.) Roxb. (seedling)	2.00	0.00206	0.0000043	0.0128	
35	<i>Psidium guajava</i> (L.) Bat. (Seedling)	3.00	0.00309	0.0000096	0.0179	
36	<i>Sida acuta</i> Burm.	3.00	0.00309	0.0000096	0.0179	
37	<i>Sida cordifolia</i> L.	19.33	0.01994	0.0003975	0.0781	
38	<i>Solanum nigrum</i> L.	1.00	0.00103	0.0000011	0.0071	
39	<i>Sporobolus diander</i> (Retz.) P. Beauv.	8.50	0.00877	0.0000768	0.0415	
40	<i>Syzygium cumini</i> Skeel. (seedling)	0.33	0.00034	0.0000001	0.0027	
41	<i>Terminalia arjuna</i> (Roxb.) Wt. & Am (Seedling)	1.33	0.00138	0.0000019	0.0091	
42	<i>Zizyphus mauritiana</i> Lamk. (Seedling)	0.50	0.00052	0.0000003	0.0039	
		969.67	1.0	0.13	2.65	0.71

ANIP= Average Number of Individual plants, D= Index of Dominance, H= Shannon's diversity index, E= Evenness.

Appendix I: Results from Two-way ANOVA that Evaluate the Effects of Site and Season on Number of Species and Number of Individual plants

Appendix I-1 Number of Individual plants and Number of Species Observed in the Three Sites in Three Different Seasons

(Data means of 10 replications)

Season	Number of Individual Plants			Number of Species		
	Site A	Site B	Site C	Site A	Site B	Site C
Rainy	1425	1234	1385.5	18	20	28
Winter	783.5	338	686	9	17	19
Summer	852.5	1918.5	837.5	16	19	23

Appendix I-2: Analysis of Variance between Number of Species $\times$ Seasons and Number of Species $\times$ Sites (Data from Appendix I-1)

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Season	74.88889	2	37.44444	9.911765*	0.028191	6.944276
Site	121.5556	2	60.77778	16.08824*	0.012226	6.944276
Error	15.11111	4	3.777778			
Total	211.5556	8				

* Significant at 5% level

Appendix I-3: Analysis of Variance between Number of Individual Plants $\times$ Seasons and Number of Individual Plants $\times$ Sites (Data from Appendix I-1)

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Season	937540.6667	2	468770.3	2.238181	0.22269	6.944276
Site	60635.16667	2	30317.58	0.144754	0.869571	6.944276
Error	837770.1667	4	209442.5			
Total	1835946	8				

Appendix J: Edaphic and other Phytosocial Variables of Three Plantation Sites

Variables	Unit	Site A	Site B	Site C
pH		6.72	4.83	6.51
O.M	%	1.75	2.11	3.02
K	Meq/100 gm soil	0.41	0.36	0.30
Ca		5.00	2.60	6.25
Mg		1.95	1.70	1.95
Total N	%	0.11	0.11	0.15
P	μ gm/gm soil	5.33	3.63	3.77
S		11.45	12.44	6.03
B		0.36	0.25	0.50
Cu		1.22	1.90	1.06
Fe		38.00	150.50	102.50
Mn		35.00	67.00	25.00
Zn		1.28	0.80	1.55
No of. Species		26	30	42
No of individual plants		1020.33	1163.50	969.67
Shannon's diversity index		2.04	2.31	2.65
Index of Dominance		0.19	0.15	0.13
Evenness		0.63	0.68	0.71

Appendix K: Correlation Results between Edaphic Factors and Some Phytosocial Parameters as Measured in Three Sites during Study Period (Data from Appendix J)

	pH	OM	K	Ca	Mg	TN	P	S	B	Cu	Fe	Mn	Zn	Nsp	NIP	H	D	E
pH	1																	
OM	.142	1																
K	.049	-.982	1															
Ca	.903	.554	-.386	1														
Mg	.995	.241	-.052	.942	1													
TN	.512	.923	-.833	.832	.596	1												
P	.641	-.668	.798	.249	.561	-.331	1											
S	-.536	-.912	.817	-.847	-.618	-1.0*	.304	1										
B	.762	.749	-.609	.967	.824	.946	-.008	-.955	1									
Cu	-.961	-.412	.231	-.987	-.984	-.730	-.403	.749	-.912	1								
Fe	-.874	.356	-.527	-.580	-.821	-.030	-.933	.059	-.352	.705	1							
Mn	-.946	-.456	.279	-.994	-.974	-.763	-.357	.781	-.931	.999*	.669	1						
Zn	.894	.571	-.404	1.0*	.935	.842	.230	-.857	.971	-.983	-.564	-.991	1					
Nsp	.179	.999*	-.974	.585	.277	.937	-.640	-.927	.773	-.445	.321	-.489	.601	1				
NIP	-.937	-.478	.302	-.996	-.968	-.779	-.334	.797	-.940	.997*	.650	1.0*	-.994	-.510	1			
H	-.035	.984	-1.0**	.398	.066	.841	-.789	-.825	.620	-.244	.516	-.292	.416	.977	-.315	1		
D	.287	-.907	.971	-.153	.189	-.676	.919	.655	-.401	-.010	-.716	.040	-.172	-.891	.065	-.967	1	
E	-.242	.926	-.981	.199	-.143	.710	-.900	-.689	.443	-.037	.683	-.086	.218	.911	-.111	.978	-.999*	1

OM= Organic matter, TN= Total Nitrogen, Nsp= Number of Species, NIP= Number of individual plants, H= Shannon diversity, D= Index of dominance, E= Evenness.

* Correlation is significant at 0.05 level.

** Correlation is significant at 0.01 level.

Appendix L

Ranking of Preferred Tree Species for Future SF Projects

Name of Species	1 st Rank P (N)	2 nd rank P(N)	3 rd rank P(N)	4 th rank P(N)	5 th rank P(N)	Total Score (P)	Rank
Aam (<i>Mangifera indica</i>)	235(47)	104(26)	57(19)	24(12)	2(2)	422	1 st
Kul (<i>Zizyphus mauritiana</i>)	60(12)	60(15)	27(9)	20(10)	9(9)	176	2 nd
Litchu (<i>Lichi Chinensis</i>)	60(12)	36(9)	6(2)	22(11)	19(19)	143	3 rd
Peyara (<i>Psidium gujava</i>)	40(8)	60(15)	9(3)	18(9)	12(12)	139	4 th
Nim (<i>Azadirachta indic.</i>)	20(4)	12(3)	69(23)	26(13)	4(4)	131	5 th
Jam (<i>Syzygium cumini.</i>)	5(1)	72(18)	18(6)	12(6)	4(4)	111	6 th
Kanthal (<i>Artocarpus heterophyllus</i>)	20(4)	36(9)	24(8)	14(7)	8(8)	102	7 th
Mehagini (<i>Swietenia mahagoni</i>)	30(6)	16(4)	27(9)	10(5)	5(5)	88	8 th
Koroi (<i>Albizia procera</i>)	35(7)	24(6)	9(3)	8(4)	7(7)	83	9 th
Arjun (<i>Terminalia arjuna</i>)	10(2)	4(1)	33(11)	8(4)	6(6)	61	10 th
Babla (<i>Acacia nilotica</i>)	15(3)	12(3)	15(5)	12(6)	5(5)	59	11 th
Medicinal Herbs	20(4)	0(0)	18(6)	6(3)	4(4)	48	12 th
Bel (<i>Aegle marmelos</i>)	5(1)	4(1)	18(6)	14(7)	5(5)	46	13 th
Ipil Ipil (<i>Leucaena latisilqua</i>)	0(0)	16(4)	12(4)	4(2)	7(7)	39	14 th
Lebu (<i>Citrus sp.</i>)	10(2)	0(0)	0(0)	8(4)	6(6)	24	15 th
Danchi (<i>Sesbania canabina</i>)	0(0)	8(2)	6(2)	8(4)	1(1)	23	16 th
Tentul (<i>Tamarindus indica</i>)	5(1)	0(0)	0(0)	8(4)	2(2)	15	17 th
Supari (<i>Areca catechu</i>)	5(1)	0(0)	0(0)	6(3)	0(0)	11	18 th
Tal (<i>Borassus flabellifer</i>)	5(1)	4(1)	0(0)	0(0)	2(2)	11	19 th
Debdaru (<i>Polyalthia longifolia</i>)	5(1)	0(0)	0(0)	2(1)	2(2)	9	20 th

Appendix L continued

Name of Species	1 st rank P (N)	2 nd rank P(N)	3 rd rank P(N)	4 th rank P(N)	5 th rank P(N)	Total Score (P)	Rank
Bohera (<i>Terminalia belerica</i>)	0(0)	4(1)	3(1)	0(0)	1(1)	8	21 st
Akasmoni (<i>Acacia auriculiformis</i>)	5(1)	0(0)	0(0)	0(0)	0(0)	5	22 nd
Haritaki (<i>Terminalia chebula</i>)	5(1)	0(0)	0(0)	0(0)	0(0)	5	23 rd
Jalpai (<i>Elaeocarpus robustus</i>)	0(0)	0(0)	3(1)	2(1)	0(0)	5	24 th
Jarul (<i>Lagerstroemia speciosa</i>)	5(1)	0(0)	0(0)	0(0)	0(0)	5	25 th
Kadam (<i>Anthocephalus chinensis</i>)	0(0)	0(0)	3(1)	2(1)	0(0)	5	26 th
Sajina (<i>Moringa oleifera</i>)	0(0)	0(0)	0(0)	4(2)	1(1)	5	27 th
Narikel (<i>Cocos nucifera</i>)	0(0)	4(1)	0(0)	0(0)	0(0)	4	28 th
Rain Tree (<i>Samanea saman</i>)	0(0)	0(0)	3(1)	0(0)	1(1)	4	29 th
Segun (<i>Tectona grandis</i>)	0(0)	4(1)	0(0)	0(0)	0(0)	4	30 th
Bot (<i>Ficus benghalensis</i>)	0(0)	0(0)	0(0)	2(1)	0(0)	2	31 st
Jamrul (<i>Syzygium samarangense</i>)	0(0)	0(0)	0(0)	0(0)	2(2)	2	32 nd
Kamranga (<i>Averrhoa carambola</i>)	0(0)	0(0)	0(0)	0(0)	2(2)	2	33 rd
Amloki (<i>Phyllanthus embelica</i>)	0(0)	0(0)	0(0)	0(0)	1(1)	1	34 th
Amra (<i>Spondias pinnata</i>)	0(0)	0(0)	0(0)	0(0)	1(1)	1	35 th
Khejur (<i>Phoenix sylvestris</i>)	0(0)	0(0)	0(0)	0(0)	1(1)	1	36 th

P= Points, N= Number

Note: Points were determined on the basis of species ranked by the respondents. Suppose five respondents ranked '*Mangifera indica*' as 1st, 2nd, 3rd, 4th, and 5th places respectively according to their preference for future SF projects; the total point of this particular species would be (5+4+3+2+1 = 15).

Appendix L

Questionnaire

Institute of Environmental Science
University of Rajshahi
Rajshahi

Serial No:

Questionnaire for research work titled "Environmental and Socio-Economic Impacts of Social Forestry in the High Barind Tract".

Declaration: Honorable respondents are being informed that data of this questionnaire will be used only for research purpose.

1. Type of SF Operation

Forest Department ☐ 1 GO ☐ 2

2. Respondent's Personal Information:

(A) Personal

Name:

Father's name:

Address:

Village:

Union:

U.Zilla:

Dist:

Age: Gender: Male ☐ 1 Female ☐ 2

Religion:

Muslim ☐ 1 Hindu ☐ 2 Christian ☐ 3 Others ☐ 4

Occupation:

Main ☐ 1 Secondary ☐ 2 1| 2| 3|

Education:

Illiterate ☐ 1 Primary ☐ 2 Secondary ☐ 3 H. Secondary ☐ 4

Bachelor ☐ 5 Technical ☐ 6 Others(Specify) ☐ 7

(B) Family

Family members by Gender

Gender	Total
Male	
Female	

Total earning members:

C. Land

Family Land Ownership:

Land use Pattern (Decimal):

Homestead Agriculture Pond Fallow Others(Please specify)

Land use in Agriculture (Decimal):

Owned cultivated Lease in Lease out Share in Share out

D. Economic Status:

Below poverty	1	(Chronic food deficit/ Mal nutrition)
Marginal	2	(Balance income and Expenditure but poor)
Middle class	3	(A little surplus)
Higher Middle Class	4	(Relatively better surplus/ Accumulation)

3. Information about Plantation**Location of Afforested Area:**

Types of Plantation: Strip (Km) Woodlot (Ha)

What are the species planted in your plantation plot?

Name of the sponsor organisations: 1. 2. 3.

Year of Plantation:

Who selected the plantation species?

Please rank five tree species you prefer the best for future SF projects?

4. Economic Benefits from Social Forestry

Benefits obtained from SF since join as beneficiary

Heads of Expenditure of cash money obtained from Social Forestry

Benefits		Value (in Taka)
Food/ Fruit	1	
Fuelwood	2	
Fodder	3	
Timber	4	
Cash income	5	
No benefits	6	
Total		

Heads of Expenditure		Taka
1		
2		
3		
4		
5		
6		
Total		

What do you hope to obtain from Social Forestry after harvesting your plantation plot?

Benefits		Value (in Taka)
Food/ Fruit	1	
Fuelwood	2	
Fodder	3	
Timber	4	
Cash income	5	
Others	6	
Total		

5. Beneficiary Selection Process

Year of joining as a beneficiary in SF:

How are you selected as a beneficiary?

By self-initiative By member of local govt. By govt. org.

By NGO By Local influential person As a member of club/society Others

6. Beneficiary Group

Please mention the number of group members in your group:

No of male/ female in your group : Female Male

In case of female beneficiaries-

Do you participate actively in SF activities? Yes 1 No 2

If no who work for you in SF activities-

7. Training of Beneficiaries

Have you got any training in plantation techniques? Yes No

If yes- Duration of training:

8. Causes of Joining SF

Please rank the causes those inspired you joining in SF

Food/fruit Fuelwood Fodder Timber Cash income Others (Specify)

9. Distribution of Benefit:

Do you think you would get fair price of forest produce from SF?

Yes 1 No 2

If no please mention the reasons-

Have you got your share benefit from harvested forest produce?

Yes No

If yes, - Please mention your stake in percentage that you have earned from total benefit-

Did you take part in extraction and valuation of forest produce?

Yes No

If no-Please mention the reasons:

10. Constraints of Productive SF

Grazing

Obstruction by local influential

Trees are stolen

Lack of Seedlings

Non co-operation of related organisations

Low economic benefits

Conflicts among group members

Inadequate land for plantation

Thinning, Pruning, and harvesting are not done by related organisations

No problem

Others (Please specify)

1
2
3
4
5
6
7
8
9
10
11

Please give your opinion about the proper maintenance and nursing of afforested area:

11. Social/Intangible Benefits from SF

Feeling of social security and unity among the member have increased

Prestige in the society has increased

Social harmony has improved

Environmental awareness has broaden

Political consciousness has enhanced

Employment opportunity has increased

Others (Please specify)

1
2
3
4
5
6
7

12. Fuelwood Supply from Social Forestry

What fuel sources do you use for family cooking?

Please mention the percentage of fuelwood of your annual fuelwood consumption that comes from SF -----%

Do you feel fuelwood scarcity in your every day life?

13. Respondents' Perception about SF and Afforestation

Do you think that afforestation has generated positive impacts on environment of your area? Yes ☐ 1 No ☐ 2

Please give your opinion about the impacts of SF on overall environment of your area-

Components of Environment		Positive change	No change	Negative change	Comment
Soil	Fertility				
	Erosion				
Temperature					
Rainfall					
Plants	Plant number				
	Plant diversity				
Bird	Bird number				
	Bird diversity				

Signature of the Respondent

Rajshahi University Library
Documentation Section
Document No. D-2586
Date. 13.2.07