EX-SITU CONSERVATION OF THREATENED FOREST TREE SPECIES FOR SUSTAINABLE USE OF FOREST GENETIC RESOURCES IN BANGLADESH

Rahman, M. M., W. Parvin, N. Sultana and S. A. M. Tarek

Silviculture Genetics Division, Bangladesh Forest Research Institute, Chittagong-4000

Abstract

The present study was carried out to advance towards the conserving threatened forest tree species of Bangladesh under ex-situ conservation system. Four thousand plants of forty eight threatened forest tree species were conserved at three areas, namely Institute of Forestry and Environmental Sciences, Chittagong University; Radar Unit of Bangladesh Air Force, Cox’s Bazar; and the Keochia research station of Bangladesh Forest Research Institute. The average 90-95% plants survived in each conservation site and the maximum average plant height was recorded as 4.0m after two years of plantation. It will provide a wider buffer for the protection of the forest gene resources.

Key words: Ex-situ conservation, threatened tree species, forest genetic resource, sustainable use, germplasm.

INTRODUCTION

Bangladesh is located between latitudes 20°34’ and 26°38’ north, and between longitudes 88°01’ and 92°41’ east. The country consists mostly of flood plains (80%) with some hilly areas (12%), with a subtropical monsoon climate (Islam 2003). In winter, temperature ranges from a minimum of 7°C to 13°C to a maximum of 23°C to 32°C. In summer, the temperature varies from 36°C to 41°C. The mean annual rainfall ranges from 143 to 434 cm (BBS 1994). The population stood at 131.6 million in 2001. Bangladesh has a total area of 14.39 million hectares, of which 9.12 million ha are cultivated, 2.14 million ha public forests, 0.27 million ha village groves and 1.64 million ha constantly under water. The remaining land area (1.22 million hectares) is occupied by tea gardens, uncultivable areas, rural and urban houses and ponds (Kibria et al. 2000). The area covered by government and village forests is about 16% of the total land area; however, only 0.93 million ha (6.5%) is under tree cover, which is about 40% of the forests controlled by the government. The remaining 60% include denuded lands (grassland, scrubland and encroached areas). About 24,000 ha of forest are lost annually as a result of homestead development, urbanization and deforestation (Anon 1992). Bangladesh, due to its unique geophysical location and a suitable climatic condition, is exceptionally endowed with a rich variety of biodiversity (Nishat et al. 2002). Nevertheless, in last years, like most other regions of the world, Bangladesh also went through a critical period unsuitable for country’s biodiversity and ecosystem. The government, along with various international conservation agencies, is trying to improve and manage this overwhelming situation.

The forests of Bangladesh cover four major vegetation types occurring in three distinctly different ecosystems, i.e. Hill forests (evergreen to semi-evergreen); Plain land sal (Shorea robusta) forests, Mangrove forests, and Village or Homestead forests. Although, once very rich in biodiversity during the last few decades all forest and ecosystems of the country have been heavily degraded (Mukul et al. 2008). There have some contradictions on the actual forest coverage of the country. Although the official forest coverage is 2.53 million ha representing nearly 17.5% of the country’s total land area, only 1.52 million ha of them are under the jurisdiction of the Forest Department (Khan et al. 2007, FAO 2006). In addition to that, most of the forests of the country are geographically located only in few districts and are poorly stocked.

Bangladesh’s forests have decreased significantly in terms of both area and health status over the last few decades. The annual deforestation rate is estimated to be around 3.3% (Khan 2004). The increasing
population of Bangladesh continues to put pressure on existing forest resources. Present productivity of forest has declined to a range of 1.5-2.5 m per hectare per annum from 7-8 m per hectare per annum that was accounted twenty years ago (MoEF 1993). Moreover, canopy closure density, number of trees per hectare and over all plant biodiversity has declined rapidly (FAO 2000). As a consequence, the quality of the forestland as ‘wildlife habitat’ has also been reduced. Forest cover loss in the country has not been comprehensively studied until now and the quantification of this loss is largely assessed by periodic visual observations.

In Bangladesh, some 2,260 species of plant reported alone from the Chittagong Hill Tracts, which falls between two major floristic regions of Asia (MoEF 1993). Until now, an estimated 5,700 species of angiosperms alone, including 68 woody legumes, 130 fibre yielding plants, 500 medicinal plants, 29 orchids, 3 gymnosperms and 1,700 pteridophytes have been recorded from the country (Firoz et al. 2004). A great number of plants are already extinct from Bangladesh. A reliable statistic on country’s plant diversity is still unavailable, nevertheless, it is anticipated that already 10% of country’s plant species have gone extinct. A recent inventory identified 106 vascular plants with risks of various degrees of threats (Khan et al. 2001). However, according to the ‘Encyclopedia of Flora and Fauna of Bangladesh’ (Volumes 5-12) on vascular plants (Pteridophytes, gymnosperms and angiosperms) about 13% species were designated as threatened (Siddiqui et al. 2007a, b, Ahmed et al. 2008b,c, Ahmed et al. 2009a,b,c,d). A few families are significantly threatened; for example about 53% species of Orchidaceae are threatened (94 species out of 179), whereas in Lamiaceae it is more than 30% (26 species out of 86). Needless to say, these threatened statuses are purely in the national context. The information in the Encyclopedia can be considered as the most recent update for Bangladesh. Among the total 3,813 angiosperm species, 449 species are threatened in their natural habitat. Many species are still being exploited to the extent that they are now listed as vulnerable or endangered with a distinct number of populations threatened with extinction. Conservation is essential for sustainable forest management and the promising potential of forestry to contribute national development objectives.

The main challenges of forest gene conservation and management are related to ongoing forest degradation and encroachment. This is a national scale problem that requires multi-sectoral solutions towards land use planning and improved livelihoods. Forest management is limited by capacity and budgetary constraints. In addition to the ecological, aesthetic and ethical consequences, loss of biodiversity and global warming pose a range of potential threats to human health, nutrition (Chivian and Bernstein 2008) and economics as a whole (TEEB 2010). Considering the above points, Silviculture Genetics Division of the BFRI has attempted to make a plan for studying the conservation of the threatened forest species under ex-situ condition.

**MATERIAL AND METHODS**

*Planting materials*

The seedlings of 48 threatened forest tree species were used for conservation programme. The seedlings were developed through different propagation methods and maintained at the nursery of Silviculture Genetics Division of BFRI, Chittagong. Seeds, branch cuttings, young twigs, branch shoot tips were used to develop seedlings through macro propagation under greenhouse and nursery condition whereas seeds and vegetative parts were used for micro-propagation in tissue culture laboratory. Three areas namely the Keochia, Research Station of BFRI, Institute of Forestry and Environmental Sciences (IFESCUC), Chittagong University (CU), and the Radar unit of Bangladesh Air Force (BAF), Cox’s Bazar were selected for conservation. Combined efforts were made among BFRI, IFESCUC, and BAF, Cox’s Bazar radar unit to raise and maintain the plantation. IUCN Red List categories and criteria of 1994 were apparently followed to determine threatened vascular plant species in Bangladesh.
Propagules development

Seed germination, seedling raising and the practice of vegetative propagation methods were emphasized to produce plant propagules.

Seed germination and seedling rising

Seeds were collected based on the flowering season of the threatened plant species through exploration of different natural habitat like the forests of Chittagong and Chittagong Hill Tracts (CHTs), Sylhet, Dhaka and Cox’s Bazar. Seeds were germinated in seed beds at mist house and direct sowing in the polybags of Silviculture Genetics Division nursery of BFRI. The seedlings were managed up to one year in the nursery and planted in the conservation site with a spacing of 6’×6’.

Propagules development through vegetative propagation

Propagation by stem cuttings

Some of the species were propagated through vegetative means by stem cuttings. Due to the availability of propagation materials, season of the year or the facilities available in the nursery, it was easy to develop root and shoot of cutting base. The cuttings were taken from the ends of the young twigs or the top of the plant. This type of cutting involves a piece of the stem plus about 3 to 4 leaves. Sometimes the tip cuttings were also used. Each piece of stem should be from 2 to 5 inches long.

Different rooting media were used for root and shoot induction at the base of cuttings; these were 100% sand, 100% garden soil, 100% sphagnnum peat moss, 50% coarse sand plus and 50% sphagnnum peat moss. The poly bag and plastic pots (5”×7”) were used as containers. After filling the containers with rooting medium and wetted these thoroughly before inserting the cuttings. The medium should be kept moist until rooting occurs. Synthetic rooting hormones Indole-3-butyric acid (IBA) and α-naphthalene acetic acid (NAA) with different concentrations (100 ppm, 200 ppm, 300 ppm, 400 ppm and 500 ppm) were used to develop root at the cutting base. The cutting base was deped into different concentrations of rooting hormones exposed for certain time, such as 10, 20, 40, and 60 minutes. The experiments were carried out under greenhouse condition to provide maximum humidity 90-100% and temperature 29°C. Depending on the type of plant species it takes 2-3 months for rooting. When the cuttings have grown roots, they were one-half inch or more in length. It was potted in a more permanent mixture of garden soil and cow dung 3: 1 and allowed them to grow under nursery condition.

Propagation through tissue culture

Development of propagules for mass propagation and conservation of threatened tree species have been done in tissue culture laboratory of Silviculture Genetics Division of BFRI since 1990. The seedlings of some of the important species like as Haldu (Adina cordifolia) were produced through tissue culture technique. The TC seedlings were also used as propagule materials in the conservation sites.

Statistical analysis

All experiments were performed as Completely Randomized Design (CRD). Data were analyzed using statistical analysis system (SAS v 9.3) and means were statistically compared using LSD test. The significance level was set up at p < 0.05.

RESULTS AND DISCUSSION

Silviculture Genetics Division of BFRI has been conducting research study on conservation and centralization of threatened forest tree species for their sustainable management since 2010. Accordingly, it has been developed the propagation methods for different species to maximize the production of plant propagules. According to the records of the Red Data Book there are 106 species of
46 families of the vascular plants of Bangladesh. Among them 48 species of 32 families were conserved at three protected areas of Bangladesh which are Keochia research station, Chittagong of BFRI, IFESCU of Chittagong University, and the Radar unit of Bangladesh Air Forces, Cox’s Bazar (Table 1).

The plant species were categories as the IUCN Red List categories (www.iucnredlist.org) near threatened, vulnerable, endangered, critically endangered and regionally extinct in the habitat. The most widely distributed family is represented by Sterculiaceae (5 species). The species were mostly distributed in the evergreen, semi evergreen and deciduous forests of Chittagong, Chittagong Hill tracts, Cox’s Bazar and Sylhet district of Bangladesh.

Table 1. List of threatened plant species conserved at IFESCU, Chittagong University, Radar Unit of Bangladesh Air force, Cox’s Bazar and Keochia Research Station of BFRI.

<table>
<thead>
<tr>
<th>Local name</th>
<th>Scientific name</th>
<th>Family</th>
<th>Natural habitat (forests)</th>
<th>Tree features</th>
<th>Current status</th>
<th>Conservation site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asok</td>
<td>Saraca asoca</td>
<td>Caesalpiniaceae</td>
<td>Chittagong and CHTs</td>
<td>Medium (20-25m height) Evergreen</td>
<td>Vulnerable</td>
<td>IFESCU, Radar unit, Kechoria, BFRI</td>
</tr>
<tr>
<td>Bandorhola</td>
<td>Duabanga grandiflora</td>
<td>Sonneratiaceae</td>
<td>Chittagong, Cox’s Bazar and Sylhet</td>
<td>Large (25-40m), Deciduous</td>
<td>Endangered</td>
<td>Radar unit</td>
</tr>
<tr>
<td>Banshpata</td>
<td>Podocarpus nervifolius</td>
<td>Podocarpaceae</td>
<td>Chittagong and Cox’s Bazar</td>
<td>Large, Evergreen</td>
<td>Critically endangered</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Barela</td>
<td>Holigarna caustica</td>
<td>Anacardiaceae</td>
<td>Chittagong, CHTs, Sylhet, and Cox’s Bazar</td>
<td>Large, Evergreen</td>
<td>Vulnerable</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Bariakat</td>
<td>Berrya cordifolia</td>
<td>Malvaceae</td>
<td>Chittagong</td>
<td>Large, Deciduous</td>
<td>Vulnerable</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Barun</td>
<td>Crataeva magna</td>
<td>Capparaceae</td>
<td>Chittagong and CHTs</td>
<td>Small to medium</td>
<td>Vulnerable</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Batna</td>
<td>Castanopsis indica</td>
<td>Fagaceae</td>
<td>Chittagong, CHTs, Sylhet</td>
<td>Medium to large</td>
<td>Vulnerable</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Bazna</td>
<td>Zanthoxylum rhetsa</td>
<td>Rutaceae</td>
<td>Chittagong, CHTs, Sylhet</td>
<td>Medium, Deciduous</td>
<td>Endangered</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Bohera</td>
<td>Terminalia bellirica</td>
<td>Combretaceae</td>
<td>Chittagong, CHTs, Cox’s Bazar and Sylhet</td>
<td>Large, Deciduous</td>
<td>Vulnerable</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Boilam</td>
<td>Anisoptera scaphula</td>
<td>Depterocarpaceae</td>
<td>Chittagong and Cox’s Bazar</td>
<td>Large, Evergreen</td>
<td>Critically endangered</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Boxbadam</td>
<td>Sterculia foetida</td>
<td>Sterculiaceae</td>
<td>Chittagong</td>
<td>Large, Evergreen</td>
<td>Vulnerable / Endangered</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Buddhunarkili</td>
<td>Pterygota alata</td>
<td>Sterculiaceae</td>
<td>Chittagong, Cox’s Bazar</td>
<td>Large, Deciduous</td>
<td>Endangered</td>
<td>IFESCU, Radar unit, Kechoria, BFRI</td>
</tr>
<tr>
<td>Chalmugra</td>
<td>Hydnocarpus kurzii</td>
<td>Flacourtiaceae</td>
<td>Chittagong, Cox’s Bazar and Sylhet</td>
<td>Medium, Evergreen</td>
<td>Critically endanger</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Champa</td>
<td>Magnolia champaca</td>
<td>Magnoliaceae</td>
<td>Chittagong, CHTs, Sal forest and Sylhet</td>
<td>Medium, Evergreen</td>
<td>Vulnerable</td>
<td>Radar unit</td>
</tr>
<tr>
<td>Chatian</td>
<td>Alstonia scholaris</td>
<td>Apocynaceae</td>
<td>Chittagong, CHT and Cox’s Bazar</td>
<td>Medium to large, Evergreen</td>
<td>Endangered</td>
<td>IFESCU, Kechoria, BFRI</td>
</tr>
<tr>
<td>Civit</td>
<td>Swintonia floribunda</td>
<td>Anacardiaceae</td>
<td>Chittagong, CHT’s and Cox’s Bazar</td>
<td>Large, Evergreen</td>
<td>Vulnerable</td>
<td>IFESCU, Radar unit, Cox’s Bazar</td>
</tr>
<tr>
<td>Dharmara</td>
<td>Stereospermum colais</td>
<td>Bignoniaceae</td>
<td>Chittagong, Cox’s Bazar and Sylhet</td>
<td>Medium, Deciduous</td>
<td>Critically endangered</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Dhup</td>
<td>Canarium</td>
<td>Burseraceae</td>
<td>Chittagong, Cox’s</td>
<td>Large, Evergreen</td>
<td>Protected</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Resiniferum</td>
<td>Gutgutya Protopium serratum Serra</td>
<td>Bacteriaceae</td>
<td>Chittagong, Cox’s Bazar and Sylhet</td>
<td>Large, Evergreen</td>
<td>Endangered</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Haldu</td>
<td>Adina cordifolia</td>
<td>Rubiaceae</td>
<td>Chittagong, Cox’s Bazar and Sylhet</td>
<td>Large, Deciduous</td>
<td>Endangered</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Horitoki</td>
<td>Terminalia chebula</td>
<td>Combretaceae</td>
<td>Chittagong, CHTs, Cox’s Bazar, Sal forest and Sylhet</td>
<td>Medium, Deciduous</td>
<td>Endangered</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Kalomenda</td>
<td>Litsea glutinosa</td>
<td>Lauraceae</td>
<td>Chittagong, CHTs, Sal forest, Cox’s Bazar and Sylhet</td>
<td>Medium, Evergreen</td>
<td>Vulnerable</td>
<td>Radar unit</td>
</tr>
<tr>
<td>Kanak</td>
<td>Schima wallichii</td>
<td>Theaceae</td>
<td>Chittagong Hill forest, Cox’s Bazar and Sylhet</td>
<td>Large size Evergreen</td>
<td>Endangered</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Kanyari</td>
<td>Gardenia coronaria</td>
<td>Rubiaceae</td>
<td>Chittagong, Cox’s Bazar and Sylhet.</td>
<td>Small to medium (15-20m)</td>
<td>Vulnerable</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Karanja</td>
<td>Pongamia Pinnata</td>
<td>Fabaceae</td>
<td>Chittagong, CHTs, Cox’s Bazar, Sylhet and Sundarbans</td>
<td>Small, Evergreen</td>
<td>Vulnerable</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Keron</td>
<td>Pongamia pinnata</td>
<td>Fabaceae</td>
<td>Chittagong, CHTs Sylhet. Sundarbans and Sal forest.</td>
<td>Medium Evergreen</td>
<td>Vulnerable</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Knema</td>
<td>Knema bengaliensis</td>
<td>Myristicaceae</td>
<td>Chittagong and Cox’s Bazar</td>
<td>Medium, Evergreen</td>
<td>Rare/ endangered</td>
<td>IFESCU, CU; Radar unit, Cox’s Bazar</td>
</tr>
<tr>
<td>Kuchila</td>
<td>Strychnos x vónica</td>
<td>Loganiaceae</td>
<td>Chittagong and Cox’s Bazar</td>
<td>Small, Deciduous</td>
<td>Vulnerable</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Kushum</td>
<td>Schleichera oleosa</td>
<td>Sapindaceae</td>
<td>Chittagong, Cox’s Bazar and Sylhet</td>
<td>Large, Deciduous</td>
<td>Endangered</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Matang</td>
<td>Carallia brachiata</td>
<td>Rhizophoraceae</td>
<td>Chittagong, CHTs Sylhet.</td>
<td>Medium, Deciduous</td>
<td>Vulnerable</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Minjiri</td>
<td>Cassia siamea</td>
<td>Caesalpiniaceae</td>
<td>Chittagong and CHTs</td>
<td>Medium to large, Evergreen or Semi-deciduous</td>
<td>Vulnerable</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Mohua</td>
<td>Madhuca longifolia</td>
<td>Sapotaceae</td>
<td>Sal forest</td>
<td>Medium, Deciduous</td>
<td>Vulnerable</td>
<td>Keochia, BFRI. Radar unit</td>
</tr>
<tr>
<td>Moos</td>
<td>Brownlowia elata</td>
<td>Tiliaceae</td>
<td>Chittagong and Cox’s Bazar</td>
<td>Medium, Semi-evergreen</td>
<td>Vulnerable</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Motor korai</td>
<td>Albizia lucidior</td>
<td>Mimosaceae</td>
<td>Chittagong, CHTs, Sal forest and Sylhet</td>
<td>Medium</td>
<td>Endangered</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Muskundo</td>
<td>Pterospermum acerifolium</td>
<td>Sterculiaceae</td>
<td>Chittagong, CHTs, Cox’s Bazar and Sylhet</td>
<td>Large, Evergreen</td>
<td>Vulnerable</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Padok</td>
<td>Pterocarpus indicus</td>
<td>Fabaceae</td>
<td>Chittagong</td>
<td>Large, Deciduous</td>
<td>Critically endangered</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Parul</td>
<td>Stereosperm umsuaveolens</td>
<td>Bignoniaceae</td>
<td>Chittagong and CHTs</td>
<td>Medium, Deciduous</td>
<td>Endangered</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Patagota</td>
<td>Firmiana colorata</td>
<td>Sterculiaceae</td>
<td>Chittagong, CHTs and Cox’s Bazar</td>
<td>Medium, Deciduous</td>
<td>Endangered</td>
<td>IFESCU, Radar unit</td>
</tr>
<tr>
<td>Rakton</td>
<td>Lophopetalum wightianum</td>
<td>Celastraceae</td>
<td>Chittagong, CHTs Cox’s Bazar and Sylhet</td>
<td>Large, Evergreen</td>
<td>Endangered</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Rokto chandon</td>
<td>Adenanthera pavonina</td>
<td>Mimosaceae</td>
<td>Chittagong, CHTs and Sylhet</td>
<td>Medium</td>
<td>Endangered</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Tabevuiya</td>
<td>Tabebuia rosea</td>
<td>Bignoniaceae</td>
<td>Chittagong, CHTs and Sylhet</td>
<td>Large, Deciduous</td>
<td>Endangered</td>
<td>IFESCU</td>
</tr>
<tr>
<td>Tali</td>
<td>Palaquium</td>
<td>Sapotaceae</td>
<td>Chittagong, Cox’s</td>
<td>Medium to large,</td>
<td>Protected</td>
<td>IFESCU</td>
</tr>
</tbody>
</table>
Tamal  
*Diospyros montana*  
Ebenaceae  
Chittagong and CHTs  
Medium, Deciduous  
Vulnerable  
IFESCU, Radar unit

Titpai  
*Milletia pegrins*  
Elaeocarpaceae  
Chittagong, Cox’s Bazar, Sal forest, and Sylhet  
Medium to large, Deciduous  
Endangered  
IFESCU

Toon  
*Toona ciliata*  
Meliaceae  
Chittagong, Cox’s Bazar, Sal forest and Sylhet  
Medium, Mixed evergreen  
Vulnerable  
IFESCU

Udal  
*Sterculia villosa*  
Sterculiaceae  
Chittagong , Cox’s Bazar and Sylhet  
Medium (15-20 m), Evergreen  
Endangered  
IFESCU

Uriaam  
*Mangifera sylvatica*  
Anacardiaceae  
Chittagong, Cox’s Bazar and Sylhet  
Large, Evergreen  
Critically endangered  
IFESCU

Vuikodom  
*Hymenodicty lonorixensis*  
Rubiaceae  
Chittagong Hills, CHT and Cox’s Bazar  
Medium to large, Evergreen  
Vulnerable  
IFESCU, Radar unit

<table>
<thead>
<tr>
<th>Conservation Sites</th>
<th>No. of species</th>
<th>No. of seedlings</th>
<th>Survival %</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFESCU Campus, CU</td>
<td>44 of 48</td>
<td>4,000 no.</td>
<td>95 ± 1.5*</td>
</tr>
<tr>
<td>Radar unit, Bangladesh Air Force, Cox’s Bazar</td>
<td>24 of 48</td>
<td>1,282 no.</td>
<td>92.33 ± 0.76*</td>
</tr>
<tr>
<td>Keochia research station, BFRI</td>
<td>4 of 48</td>
<td>350 no.</td>
<td>90.66 ± 0.76*</td>
</tr>
</tbody>
</table>

*values indicate the standard error of mean

Total 5,632 plants of 48 species were conserved under the three conservation sites. The species and their distribution in new habitat are shown in Table 1 and Fig. 1. The planting materials were developed through seed collection and seedling rising, stem cutting and tissue culture as well. The results revealed that seed germination were enhanced in the seed beds under mist house condition rather than direct sowing in polybags. However, the rooting percentage and cutting survivality were achieved 80-90% of *Adina cordifolia* in rooting media having 50% coarse sand and 50% sphagnum peat moss with 40 minutes treated with 500 ppm IBA. On the other hand, *in vitro* multiple shoots of *A. cordifolia* were developed in MS medium supplemented with (1.0 mg/L BAP + 0.5 mg/L NAA). The shoots were rooted in ½ MS medium supplemented with 1.0mg/L IBA. The plant propagules were maintained in the nursery for their growth up to the planting height. The first demonstration plots were raised in 2014 with the collaboration of IFESCU at Chittagong University. In 2015, plantation raised at radar unit of Bangladesh Air Forces, Cox’s Bazar and the Keochia research station of BFRI.

The field performance of all conserved species was found promising both in survival and growth rate in different conservation sites. About 90-95% plants survived in each conservation site (Table 2 and Fig.2).
Fig. 1. Growth performance of different species at IFESCU, Chittagong University campus after two years of plantation.

The values of forest gene conservation are equally important in meeting the long term interests of Bangladesh and its future generations. These include environmental protection and the conservation of biodiversity and natural heritage. Therefore, implementation of the National Forest Gene Conservation Strategy ensures that seed and planting materials of different populations of desired tree species will be available when a planting need arises in the country. Under these circumstances, plants protected ex situ, for instance in protected areas, are increasingly important to supplement in situ conservation (Smith et al. 2003, Sarasan et al. 2006, Engelmann et al. 2007, Li and Pritchard 2009).

Fig. 2. Conservation plot of different plant species at IFESCU, Chittagong University campus: a. Buddha narkel; b. Haldu; c. Asok; d. Keron; e. Haritoki; f. Batna; g. Boxbadam; and h. Civit.

From ex situ collections, conserved in the form of living plants, stored seeds and tissue cultures, plants can be reintroduced to their original or, where necessary, eco-logically restored habitats (Cochrane et al. 2007, Guerrant and Kaye 2007). Alternatively, new areas considered to provide more
favorable living conditions, as climate change proceeds, can be targeted (McLachlan et al. 2007, Richardson et al. 2009). Conservation is essential for sustainable forest management and the promising potential of forestry to contribute to national development objectives, such as poverty alleviation and socio-economic development has been realized.

The main challenges of forest gene conservation and management are related to ongoing forest degradation and encroachment. This is a national scale problem that requires multi-sectoral solutions towards land use planning and improved livelihoods. Despite a rapid loss and degradation of wild habitats, biodiversity conservation has received a wider attention in Bangladesh in the present years (Mukul et al. 2017, Mukul 2007). The country has also adopted various in situ and ex situ conservation measures to maintain its rich biological heritage. Declarations of protected areas, ecologically critical areas, World Heritage Site, Ramsar Sites are among the widely used ways for in situ conservation (Mukul et al. 2008). At present, the country has 38 protected areas including 17 national parks and 21 wildlife sanctuaries distributed across the country. Together, the protected areas of Bangladesh cover nearly 17.5% of the forest area and 1.8% of country’s total land area (Mukul et al. 2017, Mukul et al. 2008). In addition to that, the country has seven eco-parks, two safari parks and botanical gardens which also contribute significantly to the conservation of country’s dwindling biodiversity. However the three conservation sites could be a living germplasm center with a greater gene pool of 48 threatened tree species of Bangladesh.

The conservation of threatened forest tree species can be achieved through an integrated approach balancing in situ (conservation in natural habitats) and ex situ (conservation away from the natural habitats) strategies. In situ conservation offers the advantages of allowing natural selection to continue. However, when habitat destruction is inevitable, endangered species need to be preserved by ex situ means before they become extinct. Ex situ conservation can also provide the opportunity to study the biology of endangered species in order to eventually consider successful species recovery programs like restoration and reintroduction. It also has the advantage of preserving plant material and making it available for research purposes, without damaging the natural populations. Ex situ is therefore complementary to in situ conservation and can act as an “insurance policy” when species are threatened in their natural habitats.

ACKNOWLEDGEMENTS

The authors cordially acknowledge the Ministry of Environment, Forest and Climate Change as well as the Director of Bangladesh Forest Research Institute for the financial and logistic support to carry out the study.

REFERENCES


