CONSERVATION OF NATURAL RESOURCES AND BIODIVERSITY MANAGEMENT IN BANDARBAN, BANGLADESH

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Abstract

The Chittagong Hill Tracts (CHT) is situated in the Southeastern Bangladesh having an area of 13,295 km^2. Bandarban is one of the hill districts of CHT with diverse natural resources and ethnic communities. This paper is based on the review of published papers, reports, books related to Bandarban district of CHT giving emphasis on the landscape, natural resources, and the indigenous peoples in the CHT. The available information is synthesized to understand the overall state of natural resources degradation with special focus on land, soil, forest, fisheries, and livestock, etc. The traditional agricultural system of jhum cultivation is not sustainable due to population pressure, reduction of fallow period and soil degradation. The paper also presented the major causes of resource destruction along with the opportunities and challenges to the existing natural resource management in Bandarban. The prolonged conflict of land tenure and settlement of plain land people needs to be addressed at priority basis for the betterment of the hill people.

***Key words*:** Biodiversity conservation; Shifting cultivation; Forest encroachment; Hill forests; Restoration.

INTRODUCTION

The Chittagong Hill Tracts (CHT) comprises of Bandarban, Rangamati and Khagrachari hill districts and is situated in the southeast corner of Bangladesh. The total area of CHT is 13,295 km^2 covering about 10 percent of the total land area of the country. Geographically this area is a part of the Hindu-Kush-Himalayan region. The CHT is one of the most biologically diverse part of Bangladesh which makes up almost 43% of total forestlands in Bangladesh (Rahman *et al.* 2017). The CHT supports almost 80% of the country's total biodiversity (Nishat and Biswas 2005) and is inhibited by the people from 11 ethnic groups namely *Bawm, Chak, Chakma, Khumi, Khyang, Lushai, Marma, Mro, Pangkhua, Tanchangya,* and *Tripura* (Rasul 2009), who depend largely on forest resources to fulfill their livelihoods (Jannat *et al.* 2018, 2020). The forests of CHT are ecologically classified as Tropical wet-evergreen, Tropical semi-evergreen, Tropical moist-deciduous, Tropical open deciduous and Savannah forests (Chowdhury 2006). Forests contribute a significant portion of the economy (46%) at local and national levels, followed by crop/fruit production in the region (Ahammad *et al.* 2020, Hossain 2016). The evergreen and mixed evergreen forests of CHT are the habitat of more than 1560 species of flowering plants. Diversity is the most important characteristics of hill forest ecosystems of Bangladesh (Hossain 2016). Historically, along with the national revenue generation, hill forests provided a wide range of local and regional benefits, such as food, energy, timber, water, and health (Rasul 2009, Misbahuzzaman and Smith-Hall 2015). At present, forest areas cover almost 70% of the total lands that are either natural, planted or grasslands with scattered timber trees and bamboos. Natural forest only covers approximately 72,000 ha (≈12%) of the total forestlands in CHT (Ahammad *et al.* 2020, Hossain 2016).

Shifting cultivation, land tenure and management, forest dependency, ecosystem services, village common forests, carbon sequestration were researched in several sporadic studies in Bandarban and

CHT by Miah *et al.* (2012), Rasul (2009), Uddin *et al.* (2020), Jashimuddin and Inoue (2012). But there is not complete documentation of the natural resources and their management. Considering the context, the present study synthesized the available literature and depicted the overall situation of the natural resources and their management in the hill districts of Bandarban. It is expected to be useful to the policy makers in planning and implementing sustainable natural resources and biodiversity management in Bandarban and even in CHT.

METERIAL AND METHODS

This study is based on the review of the published papers related to Chittagong Hill Tracts (CHT) with particular focus on the forest landscape, natural resources, community, livelihood and the food availability of the indigenous peoples and the Bengalis in the CHT. It incorporates primary literature to produce relevant arguments on the stance. The paper also involves both qualitative and quantitative analyses, especially in the introductory part to strengthen the reliability of the proposition. Qualitative analyses involve texts and data observation sourced from documents-like peer-reviewed journal articles, related government, and non-government organizations (NGO) websites and academic discourses. Literature was also searched in PubMed, CABI, Elsevier, Google Scholar, and Web of Science as well as the websites of several international organizations, including the Food and Agriculture Organization (FAO), the World Food Program, and the International Food Policy Research Institute. The findings of the review were described in qualitative manner.

RESULTS AND DISCUSSION

Bandarban hill district is the second largest district of CHT with an area of 4,502 km² of which about 80% of the total land area is hilly or mountainous (Table 1). Most of the hills are arranged in north-south direction linking with the Hindu-Kush-Himalayan regions and the altitude ranges from 300 m to over 1,000 m. The highest peak (1,211 m), the Keokradang, is situated in this district. Bandarban is regarded as one of the most attractive travel destinations in Bangladesh.

Table 1. Areas (ha) of CHT under different slope classes.

Slope class	Slope (%)	Bandarban	Rangamati	Khagrachari	Total area	Percentage of land (%)
Extremely steep	>70	160,074	104,206	40,451	304,731	27.79
Very steep	50 – 70	142,596	157,636	47,794	348,026	31.74
Steep	30 – 50	57,381	124,354	77,476	259,211	23.64
Moderately steep	15 – 30	28,420	22,453	38,107	88,980	8.12
Gentle slope	5 – 15	1,220	16,557	5,325	23,102	2.11
Nearly level	<5	21,952	17,382	33,066	72,400	6.60
Total		411,643	442,088	242,719	10,96,450	

Major resources in Chittagong Hill Tract (CHT) especially in Bandarban

The major resources and economy of CHT is largely based on the forest, agriculture, fishery, and livestock sectors (Jannat *et al.* 2018).

Agriculture

Most rural households in CHT are dependent on agriculture related activities for producing food and income. Over 50% of the annual net income of all CHT households comes from different agriculture

related sources. Agricultural activities in Bandarban include shifting cultivation, ploughing lands, horticulture, livestock and poultry rearing, trees/nurseries, fishing, and making agriculture implements. More than 35 different types of crops are cultivated in CHT annually. Twenty three rice varieties and 55 crop species as *jhum* agro-biodiversity are used as cereals, spices, vegetables, culinary herbs, and oil producing plants. Agriculture crops with fruits and trees provide both subsistence uses and cash incomes for local ethnic groups (Mohiuddin *et al.* 2012).

Horticulture and high-value products

Different fruit species, e.g. banana, jackfruit, mango, and litchi are gradually replacing shifting cultivation crops due to increasing demand for cash income. Banana, a common horticultural product, is cultivated by about 25% households in shifting cultivation field for cash income during fallow periods, home gardens, etc. However, litchi, cashew nut, pineapple, jackfruit and papaya production contribute significantly to the household economy.

Forest resources

In Bandarban, about 393,547 ha forest area exists under Forest Department and Ministry of Land. The Matamuhuri and the Sangu reserve is about 74,500 ha. The district has about 292,522 ha USF under the jurisdiction of Ministry of land and 26,184 ha private plantations (Table 2). Forest composition originally was tropical semi-evergreen to wet-evergreen, deciduous, bamboo brakes and grassland. Raising commercial timber plantation on hilly lands or home gardens has become popular since the 1990s. In many villages, sloping agricultural lands particularly shifting cultivations have been gradually converted into mono plantations, mainly into teak or gamar. Forest and trees provide direct and indirect economic benefits to local communities in CHT (Jashimuddin and Inoue 2012) as well as to the national economy. However, the number of people dependent on forest-based economic activities is difficult to estimate due to a lack of available studies for the region. In CHT, more than 60% of forest products including NTFPs are used at the household level and the remaining 40% are sold at local markets to generate cash income (Misbahuzzaman and Smith-Hall 2015).

Table 2. Forest land classification in Chittagong Hill Tract (CHT).

Sl. No.	Classification	Districts			Total in ha
		Rangamati in ha	Bandarban in ha	Khagrachari in ha	
1	Gazetted Reserved & Protected Forest	234,520	74,841	23,151	332,512
2	Estimated remaining Reserved Forests	49,613	-	4,018	53,373
3	Encroached RF	2,176	-	-	2,176
4	Private Timber Plantations	22,259	26,184	8,930	57,373
5	USF under district administration	322,521	292,522	94.656	709,699
6	USF notified for RF	23,680	27,000	12,660	63,340
7	FD control (rows 1,6)	258,200	101,841	35,811	395,852
Total (rows 1,4,5)		579,300	393,547	126,737	10,99,584

Village Common Forests (VCFs)

Village Common Forests, a natural forest patch managed by indigenous communities of the CHT is yet significant repositories of food, biodiversity, and medicinal plants. VCFs are mostly small, ranging from 20-120 ha in size and consisting of naturally grown or regenerated native vegetation (Hossain

2016). VCFs are still the source of water, fuel wood, herbs, root crops, bamboo shoots, wild fruits, vines or leaves for cooking or medicinal plants necessary to sustain the lives of the indigenous communities in the CHT (Jashimuddin and Inoue 2012, Miah and Chowdhury 2004). VCFs are good examples of effective community-based forest management under certain customary rules and regulations, but current trends of forest degradation do not show any sign of hope for tribal communities and the environment. Total number of VCFs in CHT is 379 covering an area of 11,912.2 ha. However, VCFs comprise very small (0.87%) portion of total forest land in CHT (Table 3). There are 165 VCFs in Bandarban consisting of about 3661.7 ha of land (Singh 2013).

Table 3. **Village Common Forests (VCFs) in three hill districts of Chittagong Hill Tract (CHT).**

Districts	No. of VCF	Total area (ha)	Total hill forest area in CHT (%)
Bandarban	165	3,661.7	0.27
Rangamati	146	6,705.1	0.49
Khagrachari	68	1,545.34	0.11
Total	379	11,912.2	0.87

Non-Timber Forest Products (NTFPs)

NTFPs play a vital role in the traditional culture and life supporting functions of ethnic communities in the CHT as well as in the rest of Bangladesh (Miah *et al.* 2012, Jannat *et al.* 2018). However, a lack of formal economic valuations of NTFPs may often undermine the people's dependency on NTFPs and its potential benefits to regional and national economies. Bamboo and cane-made products and raw materials are highly demanded in the building construction industry and in nearby urban markets and cities. Broom grass (*Thysanolaena maxima*) has potential in hedge for erosion control and having commercial value (Khisa *et al.* 2004).

Bamboo resources

People manage and collect at least four different bamboo species for household subsistence use and commercial purposes. The available information indicates that poor households are engaged in different steps of collection, processing, and marketing of NTFPs and have relatively higher dependency on receiving annual income from forest-based economic activities. Natural forests still provide the largest stocks of bamboo, which are potential sources of forest-based economic activities in CHT. Forest bamboo species are *Melocanna baccifera* (Muli), *Bambusa burmanica* (Mitinga), *B. polymorpha* (Pharua), *Dendrocalamus longispathus* (Orah, Rupai), *D. hamiltonii* (Pencha bans), *Melocalamus compactiflorus* (Lotabans), *Schizostachyum dullooa* (Dolubans), and *Gigantochloa andamanica* (Kalibans). Muli grows in pure brakes, but the others grow sporadically in small patches (Table 4).

Table 4. Natural bamboos growing in Chittagong Hill Tract (CHT) forests.

Sl. No.	Forest Reserves	Area (ha)
1	Kassalong	164,446
2	Raikheong	77,104
3	Sangu and Mathamuhuri	74,500

Source: De Milde *et al.* 1985

Encroachment, illicit felling, over-exploitation, unscientific management, gradual conversion of bamboo forests into plantations through clear-felling and burning, gregarious flowering/fruiting, shifting

cultivation followed by uncontrolled fire and other different biotic interference have markedly reduced the areas of bamboo vegetation in Bangladesh, e.g. the annual loss of bamboo area has been 2.53% at Kassalong, 2.83% at Raikheong, 0.93% in Sangu and Matamuhuri. The average annual loss of bamboo forest area is 2.6%.

Medicinal plants

The tribal community of CHT is in a continuous search of plants for various uses, and in course of time they have accumulated much knowledge of the use of wild plants (Motaleb *et al.* 2015). It is the cultural tradition of the tribal women to collect some wild plants every day to meet their daily needs from the surrounding forest without destroying the habitats. They have a well-developed system of using medicinal plants and need to popularize for the resources through conserving the remnant natural forest patches. The ethnic groups of Bandarban have their own culture, tradition and primary health care system acquired through close observation of nature and a good number of people in Bandraban still depend upon the herbal healers and herbal medicine for treatments (Mohiuddin *et al.* 2012, Barua *et al*. 2013).

Water resources

In CHT, the main sources of water are the surface water of rivers, lakes, canals and springs, and ground water from shallow and deep aquifers. About 1,400 km of river that flows over the CHT region comprising of five rivers are Chengri, Myani, Karnafuli, Matamuhuri and Sangu (Table 5). The Sangu river is of great importance as people in Thanci, Bandarban sadar, Ruma and Rowangchari upazilas are dependent on the waterways to carry their crops and other essentials. Boat communication on the river is also being affected because of decreased water flow in the hills of Bandarban district (Table 5).

Table 5. **The major rivers that passed through Bandarban**.

Sl. No.	*River name*	Length (km)	Width (m)	Origin
1	Matamuhuri	97	>100	Myanmar
2	Sangu	177	50-100	Myanmar
3	Baghkhali	14	25-50	Bangladesh

The total length of *charas* (small streams) connected to the rivers and spreading over the CHT is more than 7,200 km. Among them, 40% flows over Rangamati, 30% both in Bandarban and Khagrachari. But the *charas* are steep in slope and can't hold water for long. When these *charas* meet rivers, they are flushed out. The annual average discharge of the Matamuhuri river is 860 m^3/s and that of the Sangu River is about 1100 m^3/s. Maximum discharge occurs from June to August and the minimum flow is observed in January-April. About 12% of average discharge is observed in the dry season in both the rivers.

Private forests in Chittagong Hill Tracts

Beyond the Bangladesh Forest Department managed forests, the ethnic people of the Chittagong Hill Tracts (CHT) own significant patches of forest areas. The estimated area of private forests in CHT is approximately 273,791 ha, which is mostly composed of teak (*Tectona grandis*) and gamar (*Gmelina arborea*) plantations. Permissions for felling and transporting trees in the CHT are required from FD. Approximately 100,000 m^3 timber is permitted annually to fell and transmit from CHT. While most of

these forests have already been converted into teak forests, the recent interest of the local indigenous people in horticulture suggests that the extent of these forests may be declining (DoE 2015).

Tourism

A contrasting topography of high hills, scenic valleys, with rich ethnic and cultural diversity offers Bandarban an ideal place for developing tourism. Bandarban, 'the roof of Bangladesh' has been referred to as a hidden paradise by the National Tourism Organization of Bangladesh (Rasul and Tripura 2016). For example, Ruma upazila holds immense potential for tourism with popular natural scenic areas like the *Nafa kum*, *Dim Pahar*, *Boga Lake*, *Rijuk waterfall*, *Darjiling para*, *Passim para*, *Double fall*, *Tahjing Dong hill*, etc.

Shifting cultivation

Shifting cultivation is a traditional land-use practice of ethnic populations in the region known as 'slash and burn agriculture' and referred to '*Jhum* cultivation'. At present, 16% of land is cultivated with this traditional system each year (Bala *et al.* 2010). Locally available paddy varieties, ginger, turmeric, maize, sweet potato, other vegetables, and banana are the most common crops in *Jhum*. The size of shifting cultivation field range from 0.5-3 ha per family. For many centuries, the indigenous communities have managed the forests in a sustainable manner by keeping the rotation of their shifting cultivation long enough (15-20 years) (Tiwari 2003). Population pressure, over cropping and soil erosion, indiscriminate illegal logging in forest areas and lack of suitable land, shifting cultivators now a days are forced to use a shortened fallow period of 3-4 years (Rasul and Thapa 2003) resulting in falling yields and drastic loss of forest coverage leading to land degradation. A rapid rise in population by endemic means and by in-migration of plains people, the construction of development infrastructures (e.g. hydroelectric projects), and government policies on the expansion of reserve and protected forests have made the *jhum* farming vulnerable (Jashimuddin and Inoue 2012). In the last two decades, the popularity of shifting cultivation has decreased. It has been modified with cropping patterns, mostly involving planting fruit (i.e., pineapple, banana, jackfruit, and mango, etc.) and trees that have increased economic benefits especially in the areas close to markets (Thapa and Rasul 2005). Although indigenous people have widely been blamed for degrading forest resources through the practice of shifting cultivation, yet some studies have revealed that they used forest resources in a sustainable way for centuries until external intervention (Tiwari 2003, Rasul 2009). Shifting cultivation has been proved to be an environmentally and economically unsuitable practice (Rasul and Thapa 2003, Rasul *et al.* 2004), and *jhumias* (shifting cultivators) face a food shortage of two to six months in a year (Jamaluddin *et al.* 2010, Nath and Inoue 2009, Rasul *et al.* 2004). Several studies, i.e. Rasul and Thapa (2006), Rahman *et al.* (2011) opined that modification of shifting agriculture with intensive crop and fruit cultivation can reduce soil erosion, sustain production, and meet the burgeoning demand for food.

Degradation of hill forests

Tree harvesting and shifting cultivation have caused the degradation of the forest landscapes in CHT. A gradual disappearance of trees through illegal felling and clearing/burning practices in shifting cultivation has increased the disappearance of forestlands (Mukul and Herbohn 2016). There are many

forces responsible for forest degradation, collectively and individually, and the trends of these forces are very complex. The deforestation and degradation of species rich hill forests are becoming a serious concern today. Except few inaccessible forest reserves, most of the hills in CHT are barren or covered with bushes and weeds. The existing land use in the CHT shows that Bandarban has the large area under forest (40.4%), Rangamati the greatest area under jhum cultivation (18%), and Khagrachari major area for flatland (Table 6). More than a quarter of land area in CHT is under horticulture and the overall forest cover is 36% (Bala *et al.* 2010).

Table 6. **Land use of three hill districts in Chittagong Hill Tract (CHT)**

District	Forest (%)	Jhum (%)	Horticulture (%)	Flatland paddy (%)	Other (%)
Bandarban	40.4	15.5	27.9	15.5	0.9
Rangamati	35.9	18.0	28.1	4.1	13.9
Khagrachari	28.9	13.1	26.8	29.8	1.4
CHT total	35.9	15.5	27.6	16.2	4.8

Source: Bala *et al.* 2010

Watershed degradation and restoration

The benefits of forests for the supply of water are multiple. It is by maintaining high water quality that natural and managed forests make their most significant contribution. By minimizing erosion, forests reduce the impairment of water quality due to sedimentation. By trapping sediments and pollutants from up-slope land uses and activities, forests help protect water bodies and watercourses. Watershed degradation has affected the lives and livelihoods of the people of Bandarban and affected food production, health, and nutrition. There are several reasons responsible for watershed degradation in CHT. It is found that integrated soil, water, nutrient and vegetation management can lead to a greater productivity and increase ecosystem resilience with the activities of mixed cropping, plantations of nitrogen fixing tree species to improve the regeneration of soil fertility during the fallow period, community-based biodiversity and forest conservation, contour planting, mulch use, composting, contour beds, terracing, vegetative check dams and land use planning can all contribute to watershed restoration (Sharma *et al.* 2007).

The degraded watershed restoration and conservation through involving indigenous community may improve the water availability of remote inhabitants. Climate resilient forest restoration and conservation, and social forestry in the buffer areas of reserved forests and areas outside reserved forests will be established in CHT in partnership with indigenous communities. Forests sustain the quality and quantity of water supply in the hilly areas. Removing forests increases soil erosion, sedimentation in the water bodies, reduces land productivity and causes major water quality problems downstream.

Illegal extraction of stones and boulders

The extraction of stones and boulders from streams and hills has been going on unabated in Bandarban. As a result, many *charas* and streams have already started to dry up. The dying streams will severely impact local agriculture where the streams are the only water source. Moreover, many are dredging hills in search of stones.

Locally extracted stones are being used in various development projects instead of stones from Sylhet. The enticement of easy cash has attracted many influential peoples. Unrestrained stone extraction in at least 200 streambeds strewn across the hills of Bandarban is jeopardizing the livelihoods of 11 ethnic communities and taking a toll on the biological diversity of the forest. The Bangladesh

Marma Student Council (BMSC) voluntarily began a six-month survey in November 2018 to study the overall impact of stone extraction (May 24, 2018, The Daily Star). It was also reported that 1,800 maunds of hill rocks and boulders are collected daily in Bandarban (https://www.thedailystar.net/backpages).

Tobacco cultivation

The traditional agro-practice (Jhum) in CHT is currently struggling to sustain. It is due to shorter crop cycles, limited availability of land and population pressure. The tendency to undertake tobacco cultivation in lieu of jhum cultivation in Bandarban appeared to be significantly high. It is because tobacco cultivation is more significant economically than jhum. But, jhum cultivation is much more less costly. Tobacco cultivation has negative impacts on the environment. It reduces soil fertility, increasing soil erosion, diseases, and water pollution. Tobacco also needs firewood for making barn and curing leaves and wood for curing tobacco in Bandarban is 35,167 t (Bala *et al.* 2010).

Mono-horticulture and root crops

Increased horticultural activities with one or two species may decrease the genetic resources of the cultivated crops. Uncertain market and failure in productivity may bring the people in risks of their investments. Root crops, e.g. ginger, turmeric, arum, etc. also increase the soil erosion.

Use of herbicides and pesticides

Recent trends in using herbicides/pesticides are also making the local ecosystem health vulnerable in hill districts. The indiscriminate application of chemicals for controlling weeds are deteriorating the quality of soil and degrading water quality.

Landslide and flush flood- recent calamities in CHT

The land slide of 14th June 2017 caused 130 death including army men in CHT. It had been the worst landslide since 2007, and several people still living in the bottom of the hills is in risk of landslide. Four people already died recently in a landslide in Bandarban sadar (Hossain *et al*. 2019). The Thanchi and Lama bazars are the regular victims of flush floods. Landslides are common during the monsoon. These occur from soil erosion, deforestation, and faulty agricultural practices, etc. Landslides cause siltation in the rivers. With increased forest degradation over the years, the frequency of natural disasters, such as landslides and floods has intensified. In this situation, Disaster Risk Reduction strategy is crucial as it helps to identify, assess, and reduce the risks of disaster (Hossain *et al*. 2019).

Strategies for reforestation

Forest conservation practices

Forests are important repository of biodiversity, with the highest concentration of native species in the country being found in CHT (Arannayk Foundation 2010, Hossain 2016), but 25 plant species are under threat of becoming extinct (Khan *et al.* 2007). As such, the conservation of forest biodiversity is important to sustaining the valuable benefits it provides for the region. Many of the plant species have important medicinal uses. At least 69 plant species identified by local ethnic people contribute to primary health care. Most of the Forest Department's initiatives were centered on the declaration of reserve forests, protected forest, facilitating plantations, and establishing management boundaries.

During the 1980s and 1990s, the Chittagong Hill Tract Development Board **(**CHTDB) also undertook fruit- and rubber-based agroforestry programs on 6,986 ha of land for settling shifting cultivation practices. The goals of the programs were to increase agroforestry practices for cultivating crops and to increase fruit/timber tree cover. It was for that limiting the expansion of shifting cultivation practices to reduce loss of trees. The monoculture plantation approach failed to achieve conservation benefits due to the focus on increasing tree cover rather than restoring biodiversity (Islam *et al.* 2007). A few small patches of natural forest cover (approximately 700-800 ha) scattered throughout CHT are still the sources of valuable plants and watersheds (Ahammad *et al.* 2020).

Forest Landscape Restoration (FLR)

Over the time both environmental context and the needs of the people will have to face changes. Restoration to some hypothetical pre-intervention state may be neither realistic nor desirable. People have modified the landscape in the ways that suit their immediate needs and reversing this trend is socially and economically problematic. Investments to restore a severely degraded forest are often not justified unless the pressures that have led to degradation are removed.

FLR may be a strategy for forest management/conservation in Bandarban. It seeks to restore the functions that forest provides within the landscape. It provides a natural link between conservation and development by restoring the goods and services that forested landscapes provide to both people and biodiversity. It should be implemented at a landscape scale rather than a single site. The FLR concepts for forest management in CHT is the options for a package of solutions, which may include practical techniques, such as agroforestry, enrichment planting and natural regenerations at a landscape scale, but also embraces policy analysis, training, and research.

Restoration through Assisted Natural Regeneration (*ANR*) *and Enrichment Plantation*

The fragmented patches of secondary forests remain in many hilly lands in CHT. It appears that if a secondary degraded forest or land with few seed trees is left without any human interference, natural regeneration can establish. Many of such patches have come to the shape of a forest by 8-10 years. Enrichment plantation and aided regeneration with indigenous ‘niche’ species plantation will help in the early restoration of natural forest ecosystems in the hill forests areas. Protecting secondary forests and habitats from fire by following proper fire management will also help in restoring the forest ecosystem naturally (Kamruzzaman *et al.* 2018).

Secondary degraded forests in hill forest areas have the potential to manage through regeneration from the existing soil seed banks. The minimum required number of pre-existing seedlings to implement ANR depends on the acceptable length of time for the forest to be restored and site-specific conditions that influence the rate of forest recovery. As a general reference, a density range of 200-800 seedlings (>15 cm in height) per hectare has been suggested for ANR reforestation, and it has been estimated that at least 700 seedlings/ha are needed during the early treatment period to achieve canopy closure within three years. To ensure further successional development, remnant forest should be in proximity so that there would be sufficient input of seeds.

But several indigenous tree species in hill forests also had the potential of regeneration through coppice shoot production. If the coppice shoots after felling are managed properly, the forests may be

managed for 4-5 rotations without further establishment of new plantations. However, managing such forests need to consider the age and diameter of felled trees, rate of stump deterioration, height and characteristics of the stumps, timing or season of felling and the number of shoots retaining per tree.

Local knowledge and wisdom

The ethnic community of Bandarban has traditional knowledge, practices and technologies which are unique to their culture and society. The knowledge and practices are environmentally sound and socially appropriate (Khan *et al.* 2007, Mohiuddin *et al.* 2012). Traditional knowledge supports livelihood, influences lifestyle, land use planning, and resource conservation. Mohiuddin (2009) documented 26 traditional knowledge practices in Bandarban hill district. He identified 289 ethno-medicinal and food plants growing in wild habitat in Bandarban.

Forests provide a wide range of environmental services including biodiversity conservation, watershed protection, soil protection, and climate change mitigation. Then majority of the population of Bandarban depends on subsistence farming, popularly known as Jhum. Agricultural practices can no longer sustain the population because of recent increase in environmental degradation and a low capacity to adapt to the impacts of climate change. Bandarban provides important ecosystem services which can play a significant role in economic development, environmental protection, ecological sustainability, and human wellbeing of the hill people. Vast barren hilly lands must bring to vegetation cover with multipurpose native tree species rather than the mono-plantation of teak only. Site adaptation and site suitability need to be considered for afforestation and reforestation programs, so that soil erosion and landslide must be minimized. Efforts should be made to revive the traditional water sources, springs, and protect village common forests for a secure water source.

Bandarban offers opportunities as well as challenges. Land tenure ownership conflicts, lack of effective management, inter-sectoral policy conflicts, extensive dependency on forest resources, coupled with their ignorance about the environmental importance has caused severe depletion and degradation of forest resources in Bandarban in the last couple of decades. However, the livelihood of the hilly people could be improved by utilizing its untapped potentials as it has a unique diversity, culture and beautiful landscape and attracting tourist spots.

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