

Conservation letter

A review of the present threats to tropical moist deciduous Sal (*Shorea robusta*) forest ecosystem of central Bangladesh

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Abstract

The tropical moist deciduous Sal (*Shorea robusta*) forest ecosystem of central Bangladesh is currently in a critical situation. Destructive anthropogenic and natural impacts coupled with overexploitation of forest resources have caused severe damage to the forest ecosystem. Sal is usually harvested for construction works, fuel wood, timbers, tannins, pillars, and furniture making purposes. The rapidly expanding agriculture in the forest land is a significant threat to the Sal forest ecosystem. This forest has been rapidly exhausted in recent times due to rubber monoculture and expanding commercial fuel-wood plantations. Due to illegal cutting, encroachment of forest areas, and illegal poaching of wildlife, the Sal forest is losing biodiversity at an alarming rate. The present status of the Sal forest ecosystem has been briefly discussed in this paper. After reviewing contemporary literature and analyzing findings of published research regarding the present threats to the Sal forest ecosystem of Bangladesh, this study recommends adoption of a sustainable forest management strategy based on scientific concepts of advanced silviculture. Furthermore, the requirement of further scientific research for better understanding of the Sal forest ecosystem has been stressed. Finally, this paper asserts that conservation and protection of the Sal forest ecosystem of Bangladesh can be achieved if sustainable forest management strategies are developed by involving all relevant stakeholders in the policy formulation process.

Key words: Sal forest; Threats; Biodiversity; Anthropogenic impacts; Conservation; Sustainable management; *Shorea robusta*

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Introduction

Bangladesh is a small South Asian country. The absolute location of Bangladesh lies between 20°34' and 26°38' north latitude and 88°01' and 92°41' east longitude. The total geographic area of Bangladesh is approximately 14.40 million hectares of which 13.46 million hectares are land surface and 0.94 million hectares are rivers and other inland water bodies [1, 2]. According to a recent estimate of the Bangladesh Forest Department, the country has only 17.5% (2.52 million hectare) of forest coverage [3]. The Sal forest covers about 0.12 million hectares of land comprising about 4.7% of the total forest area of the country [3]. One of the peculiarities of forest resource distribution in Bangladesh is that the resources are very eccentrically distributed. More than 90% of the government forests are concentrated within 12 districts in the eastern and southeastern regions of the country [1]. The importance of Sal forests lies in the fact that these are the only natural forest resources of the central and northern parts of Bangladesh where the vast majority of the population dwells [3].

Historically, the agrarian rural people around the forests have been heavily dependent on Sal forests for their livelihood. People living in close proximity to the Sal forest, particularly various ethnic groups such as the Garos and Hajongs, totally depend on its resources to satisfy many of their basic needs. They use these forests for food, fuel, medicinal herbs, raw materials for construction of houses, boats, and furniture, and many other items of trade and commerce [4]. This study area has a high population density – 975 persons per km² [5]. As a result, demand for lands for both settlement and agricultural use within forested areas has accelerated the rate of deforestation with loss of ecosystem productivity and biological diversity, leading to overall environmental deterioration in the area [6, 7].

The anthropogenic impacts on Sal forest have increased rapidly over past decades. The Food and Agricultural Organization (FAO) estimated that about 36% of the Sal forest cover existed in 1985; while in 1990 only about 10% of the forest cover remained [8]. It has been reported that central Sal forests are the most threatened ecosystem of Bangladesh [9]. Currently these important ecosystems are deteriorating due to several anthropological and natural threats. This study reviews present threats to the central moist deciduous Sal forest ecosystem of Bangladesh and proposes recommendations in order to conserve this important forest ecosystem.

Methods

Study area

The Sal forests have a fairly wide but interrupted distribution in the drier central and northern part of the mainland of Bangladesh. These forests mostly occur in the Gazipur, Tangail, Mymensingh, Jamalpur, Comilla, Sylhet, Dinajpur, Thakurgaon, Rangpur, and Rajshahi districts. The majority of the Sal forests lie in the districts of greater Mymensingh and Tangail, which is the largest belt, also known as “Modhupur Garh” [4]. Based on geographic location, Sal forests in Bangladesh can be divided into two categories: the central plain land Sal forest and the northern plain land Sal forest. The central Sal forests are distributed in the Dhaka, Gazipur, Tangail, Mymensingh, and Jamalpur districts, including some patches in the greater Comilla and Sylhet districts of Bangladesh (Fig. 1).

About 86% of Sal forest land is situated in this central region and the remaining 14% of Sal forest belongs to northern part of the country [9]. Sal forest lies on Plio-Pleistocene terraces in the central part of Bangladesh [10, 11]. The texture of the forest soil in this area is generally sandy loam to silty loam. The organic matter content in surface soil ranges from low (<1.5%) under grassland to moderate (2-5%) under forest cover. The forest soil is acidic in nature (p^H=5.2 -5.5) [11].

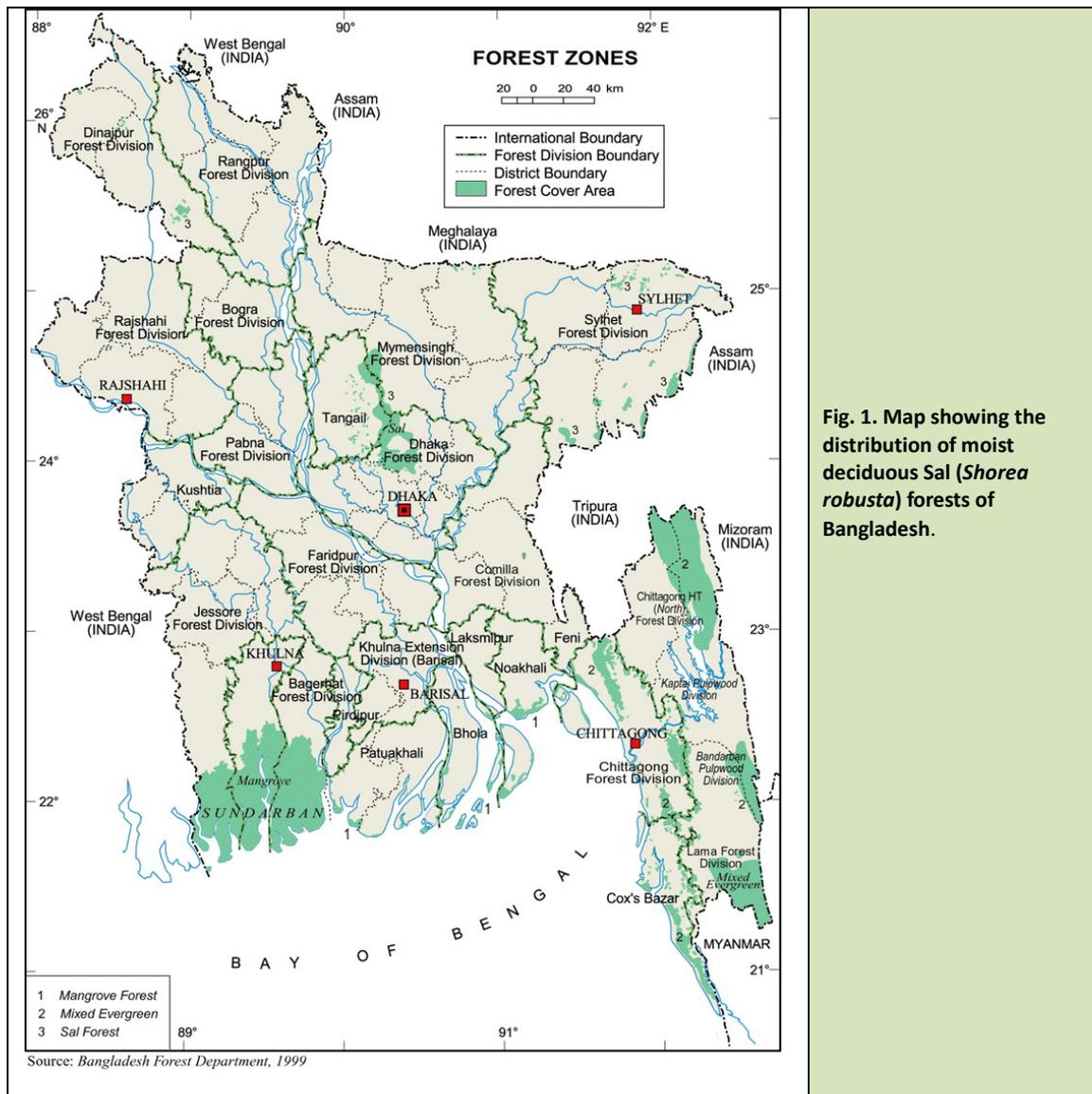


Fig. 1. Map showing the distribution of moist deciduous Sal (*Shorea robusta*) forests of Bangladesh.

The climatic conditions are relatively uniform over the central deciduous forest area. The mean annual rainfall increases from around 2,000 mm in the south to more than 2,300 mm in the north. The mean annual temperature is 26.3 °C and the average maximum and minimum temperatures are 27.5 °C and 18.5 °C, respectively [4]. The Sal forest ecosystem supports a rich and diverse variety of flora and fauna, which includes 221 plant species and 220 animal species [12, 13]. Though Sal is the single most important tree species in this forest (Fig. 2), approximately 500 undergrowth species have been reported in association with Sal trees [4]. The special type of microclimate prevailing in the Sal forest ecosystem, with relatively higher mean annual temperature and greater rainfall particularly during the rainy season, facilitates the rich association of undergrowth diversity in this forest type [4, 14]. It has been reported that 24 species of climbers, 27 species of grasses, 3 species of palms, 105 species of herbs, 19 species of shrubs, and 43 species of trees have been found in the Sal forests [12]. Similarly, animal species richness is also high in this forest (Fig. 2). A total of 220 species of vertebrates, including 12 amphibians, 25 reptiles, 148 birds, and 35 mammal species, are found in the Sal forests [13]. The Sal forest was well known for its peacock (*Pavo cristatus*), tiger (*Panthera tigris*), leopard (*Panthera pardus*), elephant (*Elephas maximus*), clouded leopard (*Neofelis nebulosa*), and sambar deer (*Cervus*

unicolor), which have disappeared due to ecosystem deterioration and habitat loss [12]. Moreover, the capped langur (*Trachypitecus pileatus*), which was abundant in this forest has been enlisted as an endangered species by the IUCN in 2008 due to habitat loss and degradation (Fig.2) [15].

Information reviewed

For assessing present threats to Sal forest in central Bangladesh, data were obtained through literature review, by exploring reliable relevant web resources, making use of Bangladesh Forest Department library resources particularly with reference to various policy documents, field document and project reports, such as forestry master plans, peer-reviewed journals, as well as direct observations in the field.



Results

Present major threats to the Sal forest ecosystem

The Sal forests have been facing great threats mainly due to their geographical location and flat topographical condition (4). For example, being the only available forest resources in the central plain lands and with readily accessible topography, these forests are under stress to meet various needs including fuel wood, fodder, construction materials, and recreation of the surrounding population. The increased population with few alternative employment opportunities poses a serious threat to the Sal forest—in fact this has been identified as the main cause of Sal forest destruction [5, 7, 9, 16]. For example, the decadal (1991-2001) population growth rates in the Tangail and Mymensingh districts, where many of the Sal forests are located, are 8.6% and 12.7%, respectively [17]. The unemployment rates in these districts were 8% and 7% respectively, in the 1990s [18]. These unemployed people naturally tend to extract resources from Sal forests, engaging in illicit activities that cause degradation of the forest. Several studies and reports have noted that Sal forests in Bangladesh are threatened due to over-exploitation, illegal cutting, encroachment, rapidly expanding agriculture, poaching, industrial development, urbanization, plantations (with invasive species), grazing, pollution, management failure, disease, and climate change [3-5, 8-10, 16]. However, for the convenience of the discussion, threats to the Sal forest ecosystem could be classified into two groups: (1) anthropogenic threats and (2) natural threats.

1. Anthropogenic threats

Over-exploitation

Over-exploitation of forests to meet the growing requirements of the expanding population, as explained above, is one of the main threats facing the Sal forests. These forests have been exploited for timber, fuel wood, bark tannin, animal fodder, native medicines and food (e.g., fruits, honey and wild life) for centuries, but recent population pressure has greatly increased the rate of exploitation, leading to serious degradation of the forest. For example, indiscriminate exploitation of the Sal forest over the centuries has converted the thickly stocked forests with numerous tree species of the past, such as sal (*Shorea robusta*), palash (*Butea monosperma*), haldu (*Adina cordifolia*), shidah jarul (*Lagerstroemia parviflora*), bazna (*Zanthoxylum rhetsa*), hargoja (*Dillenia pentagyna*), koroï (*Albizia spp.*), udhal (*Sterculia villosa*), bahera (*Terminalia belerica*), kurchi (*Holarrhena antidysenterica*), haritaki (*Terminalia chebula*), pitraj (*Aphanamixis polystachya*), sonalu (*Cassia fistula*), amlaki (*Phyllanthus emblica*), into a depleted forest [4, 19]. These forests formerly covered extensive tracts of the country [3], but at present, there are wide gaps and grassland areas within the sparse Sal forests. It is reported that more than 60% of these forests were densely wooded in the late 1970s. The area under tree cover has been reported as 36% in 1985 while only 10% remained in the 1990s [8].

Illegal cutting

Due to illegal cutting the Sal forest is rapidly disappearing, and consequently biodiversity of the area is shrinking at an alarming rate [8]. In the first half of this decade, approximately 25,101 hectares of Modhupur Sal forest were illegally cut, a figure which represents about 12% of Sal forest area [20]. The poor livelihood conditions and lack of alternative income-generating opportunities of the population in the Sal forest areas have been exploited by the timber traders to engage them in illicit forest cutting and other activities that are detrimental to the Sal forest ecosystem [21].

Encroachment

The encroachment and denudation of forests have usually been led by the local poor and by illegal timber traders. However, more recently, the Sal forests are being illegally occupied by local politically and financially influential individuals, groups of individuals, and institutions [22]. A total of 8,869 hectares of forest land have already been encroached and the number of encroachers are about 100,000 [23]. The encroachment rate is about 1% yr⁻¹ in the Sal forest area [22].

Expanding agriculture

Rapidly expanding agriculture poses a crucial threat to the Sal forests in Bangladesh. Significant areas of forest land have been illegally converted into agricultural lands. Though an up-to-date forest inventory is unavailable, it is estimated that the forest area has been reduced by more than 50% since the 1970s [5]; much of this land is believed to have been converted into agricultural lands by encroachment (Fig. 2).

Poaching

Historically, poaching is a major threat to plain land Sal forest. These forests traditionally belonged to feudal lords who took no responsibility for the protection of these resources; rather they had used them as their hunting ground, which has contributed to indiscriminate poaching of wildlife in the area [3, 23]. It has been reported that while some wildlife species such as peacock, tiger, leopard, elephant, clouded leopard, and sambar deer have disappeared from the Sal forests, others such as jackal (*Canis aureus*), civet (*Viverra zibetha*), jungle cat (*Felis chaus*), pythons (*Python* spp.), kraits (*Bungarus fasciatus*), cobras (*Naja* spp), frogs (*Rana tigerina*), and jungle fowl (*Gallus gallus*) have decreased remarkably because of poaching and habitat loss [14]. The situation has further been exacerbated due to the perception of the forest policy makers that these forests habitats are unimportant for biodiversity conservation and the resultant lack of management strategies and attention to protecting wildlife from poaching [4].

Table 1 Population Size and growth rate of major urban settlement near Sal forest area

Name of the urban area	Population size	Annual growth rate (%)
Mymensingh Sadar	225,811	2.5
Tangail	128,785	2.2
Gazipur (Sadar and Tangi)	588,492	4.0
Dhaka City	6,732,968	4.0

Source: 2001 and 2007 BBS pocket book. See ref [43-44]

Urbanization

Urbanization destroys the forest and also acts as a barrier to wildlife. A number of major urban settlements, such as Gazipur, Tangail sadar, and Mymensingh sadar including Dhaka city, are in close proximity to the main Sal forest areas of the central region. These urban settlements have large populations with high growth rates (Table 1). Such urban settlements lead to development of road networks and other infrastructures, which degrade the quality of wildlife habitat. For example, two road network improvement projects totaling 62.2 km of length have been undertaken in the Sal forest areas of Mymensingh [24]. Such road construction work isolates the population of the wildlife species from feeding grounds and natural migration routes and limits breeding between larger groups. Road construction has made Sal forest more accessible, so anthropogenic disturbances can easily take place in the forest areas. A firing range of the Bangladesh Air Force was established on about 405 hectares of Sal forest land [20], which is a source of noise pollution as well as a serious threat to wildlife habitat.

Plantations

The Sal forest has been rapidly exhausted in recent times due to commercial rubber monoculture plantations and Asian Development Bank (ADB- funded “social forestry” in the form of woodlots (for production of fuel wood) and agroforestry. The “social forestry” that was initiated in 1989-1990 was preceded by a rubber monoculture that destroyed a significant part of the Sal forest. Rubber plantations in particular are among the major factors that have changed the Sal forest forever. The Modhupur Sal forest is an example; out of 18,623.48 hectares, 3,157.89 hectares were allocated for rubber cultivation in the Tangail area [20] and another 40,000 hectares of Sal forests were planned for woodlots and agroforestry plantations under the Forestry Sector Project [25]. However, introduction of several invasive species in plantation forestry is one of the biggest threats to the biodiversity of natural Sal forest [26]. Invasion of exotics may cause major loss of biodiversity and species extinction either due to direct replacement by the exotics or indirect effects on the ecosystem. Over the last forty years, the Sal forests have decreased drastically due to new plantations with exotic species [27], which disregard the principles of silvicultural systems and the impacts of the invasive species on the Sal forest ecosystem. The Bangladesh government is trying to reforest the area with some fast growing exotic species such as Akasmoni (*Acacia auriculiformis*) and Eucalyptus (*Eucalyptus camaldulensis*) that are known as invasive species.

Scientists argue that these exotic species are detrimental to biodiversity of the area and may transform the local ecosystem into arid landscape because of their physiological requirement for increased water uptake [27]. Table 2 presents a list of species planted in Sal forests including the area covered by each species. It can be seen that about 70% of the area is planted with exotic species while only 30% of the area is planted with indigenous species. Furthermore, the most extensively planted exotic species in Sal forest area are: *Acacia auriculiformis* (26.1%), *Eucalyptus camaldulensis* (24.6%) and *Acacia mangium* (18.7%). The remaining 30% of the area is occupied with all other species including Sal, which is the original climax species in these areas and represents only 12% of the plantation programs [27].

Grazing

It is reported that the degradation of Sal forests resulted from heavy and haphazard grazing [28]. Grazing is one of the leading causes of devastation and degeneration of coppiced forests into rooted waste and scrub forests. Grazing also makes the ground compact by constant trampling, which in addition to other types of damage, greatly contributes to erosion of the surface soils. In addition, it is noted that an increase in grazing intensity decreases the fine soil particle content in forest soil [29].

Table 2: Area covered with plantation species in Sal forests of central Bangladesh.

Planted species (Scientific name)	Local name	Area planted (hectare)	% area of the total plantation
<i>Acacia auriculiformis</i> ¹	Akashmoni	818.74	26.1
<i>Eucalyptus camaldulensis</i> ¹	Eucalyptus	773.32	24.6
<i>Acacia mangium</i> ¹	Acacia	587.44	18.7
<i>Shorea robusta</i> ²	Sal	380.89	12.2
<i>Tectona grandis</i> ²	Shegun	333.85	10.6
<i>Terminalia arjuna</i> ²	Arjun	92.35	3.0
<i>Lagerstroemia speciosa</i> ²	Jarul	69.25	2.2
<i>Cassia siamea</i> ²	Minjiri	37.00	1.2
<i>Swietenia mahagoni</i> ³	Mehegoni	27.85	0.9
<i>Gmelina arborea</i> ²	Gamari	15.50	0.5
Total		3136.20	100

¹ Exotic invasive species; ² indigenous species; ³ exotic but not invasive. See ref. [27, 45]

Pollution

Pollution from chemical contaminants certainly poses a threat to species and ecosystems. Although no published data for the central Sal forest of Bangladesh are available, a study from the Indian portion of the Sal forest revealed that air pollution affects the phenological calendar, soil nutrient status, leaf nutrient concentrations, amount of soil bacteria, fungi, actinomycetes, and soil enzymes. For example, Kosla and Pamer [30] reported that the dustfall adversely affected the phenological calendar of Sal. Their study revealed that the deposited particulate pollutant on Sal trees caused an increase in soil pH, rendering soil conditions unfavorable for Sal trees. The study noted adverse changes in sulphur, phosphorus, calcium, and potassium contents in Sal forest soil in the polluted areas. Also, quantitative enumeration of soil-microbe studies showed a change in their population levels, depending upon the amount of pollution the site received; ultimately the litter decomposition was also affected. The total sugar content in polluted leaves was reduced while protein and phenol contents registered an increase. The ascorbic acid, chlorophyll, and starch contents were found to be lower in the highly polluted sites. Leaf RNA contents were reported to be increased while leaf DNA contents showed erratic behavior in the polluted sites. Pineapple and banana plantations have expanded in the Sal forest in recent times, with excessive use of pesticides, including DDT and imported hormones to make the fruit grow bigger and ripen quicker, posing a serious concern [31]. These chemicals also kill different varieties of insects that are beneficial to the soil and environment. The soil has taken on a yellowish hue from the overuse of insecticides and experts fear that serious damage has occurred to the upper layer of the forest soil, which may lead to complete loss of soil fertility within a few years [20]

Management failure

In the early 1950s and 1960s the Bangladesh Forest Department (BFD) raised Sal plantations over large areas. Over the course of the years most of these plantations have disappeared, leaving only a few patches. Later, in the 1970s, BFD raised plantations of moderately fast-growing indigenous species on recovered encroached lands. Most of these did not survive either. Then in the 1980s, plantations of eucalyptus and acacia met with the same fate, except some plantations in the Rangpur, Dinajpur, and Rajshahi divisions. Under the "Thana Banayan Plantation Program," enrichment and agroforestry plantations have started again in the Sal forest areas [32]. The Sal forest is disappearing because of three main reasons: failure of officials and institutions to effectively manage Sal forest resources; poor planning and knowledge of forest land use; and implementation of a development plan that does not include environmental protection. Although the Department of Forests has taken control of the Sal forest, the protection of these resources has not been ensured. Rather, a tree-cutting moratorium was put in place in 1972, which stopped neither encroachment nor illicit felling because of

the failure of forest officials and the Forest Department as an institution to formulate and implement an appropriate management strategy [23]. While research data concluded that the lands in the remnant Sal forests are not suitable for agriculture without irrigation [33] and there are no possibilities of extending irrigation facilities in the Sal forest areas [23], agroforestry plantations were undertaken as a management strategy to replenish the Sal forests [34].

2. Natural threats

Pests and diseases

Sal forests are under threat by an insect infestation, popularly known as Sal borer (*Hoplocerambix spinicornis*). It kills trees silently with the only visible indications the sawdust collected at the stumps of the trees and also slow withering of the branches from the top of the tree. Within a short time the entire tree will dry up and die off [35]. Also, die-back of Sal seedlings due to attacks of nematodes and root borer (e.g., *Pammene theristhis*) plays an important role in regeneration failure of Sal forests [36]. *Cylindrocladium floridanum* and *C. scoparium* causing leaf spot and blight in *Shorea robusta* are reported from India [37].

Present management system and its problem

Most of the Sal forests originally belonged to feudal landlords and were not put under scientific management for a long period [38]. The Forest Department gradually assumed responsibility for management after nationalization of these forests in the 1950s. The Sal forests have been managed under two working circles: (a) a community forest working circle, and (b) a commercial forest working circle [39]. In both circles, silvicultural prescriptions for Sal forest management include: clear-felling followed by simple coppice, and coppice with a standard system that allows keeping some mature trees as shelter-wood. Thinning is applied on a 10-year cycle to improve the existing crop based on a rotation of 100 years; and afforestation of clearings operated under a taungya (shifting cultivation) system [4]. However, the magnitude of deforestation, soil erosion, and degradation of the land in the Sal forest areas has become even worse. None of these silvicultural practices sustained the Sal forests and they continued to deplete in size and stocking [40] with the exception of some plantation programs. Commercial woodlot plantation operations have been carried out extensively throughout the central Sal forest areas without considering the long-term adverse effects on the ecology of the forest. About 16,000 ha of woodlots have been established in degraded and encroached tropical moist deciduous or Sal forests under the Dhaka Forest Division with the primary objective of producing fuel wood for local household consumption [41, 42]. When woodlot blocks were being established, hundreds of vehicles including trucks were seen carrying logs out of the forest [26]. In such practice of forestry, little attention is paid to the regeneration of the natural forests. In 1994, the government initiated participatory forestry in natural degraded forest lands including deciduous Sal forests from the mid-80s of the previous century. Although the results of such a management shift are yet to be assessed, there have been discussions and concerns that due to introduction of fast-growing exotic species and destruction of Sal regeneration, the forest composition and ecological functions of the forests have been changing in ways that will render these forests less sustainable and destroy the habitat of the wildlife [20, 27].

Current management practices are inadequate and inefficient to manage the Sal forests sustainably. As identified in the Forestry Sector policy document, many of the Sal forest management policies cannot be successfully implemented due to the following main causes: population pressure, poverty, high demand for fuel wood, negative influence of local and political elites, and encroachment of forest land by locals [33]. Corruption at different levels of management systems, illegal felling of trees, smuggling of wood, and poaching of wildlife are some of the major constraints in successful implementation of development projects [6, 18]. There are continual claims that the law-enforcement agencies and the management bodies themselves are sometimes engaged in the felonious actions. The antagonistic relationship between the Forest Department and

locals is an obstacle for effective Sal forest management. If the situation prevails as it is, no rule, policy, or regulation will be able to resurrect the valuable resources in the Sal forests.

Conservation and sustainable forest management for Sal forest ecosystem

Internationally, forest ecosystem management attention seems now to have been generally shifted from management for a single objective (often wood production) to a sustainable ecosystem approach that tries to incorporate into forest management the principles of equity in resource utilization and participation for sustained production of multiple outputs, by recognizing the hopes and aspirations of different stakeholders interested in the future of the natural forest resources. Environmental destruction in a country or region affects other regions. Conservation of nature at the local level strengthens and contributes to regional and global nature conservation. At the international and national policy levels, it is today accepted that Sustainable Forest Management (SFM) depends upon several factors such as: (1) integrated management for all forest values—wood and other items and services, (2) meaningful participation of all stakeholders, (3) landscape-level planning and management, and (4) comprehensive monitoring, evaluation, and reporting on indicators of sustainability. Most of the Sal forests in Bangladesh are now substantially degraded and poorly stocked [34]. In this crucial time it is necessary to review the current management strategies of Sal forest ecosystem for the future benefit of all stakeholders. The future of this ecosystem depends on the successful and effective implementation of a sustainable forest management plan. For proper management and protection of the existing Sal forest areas from the present threats, a forest management plan should be formulated and implemented based on sustainable forest management (SFM) principles as illustrated in Fig. 3.

Implications for conservation and protection of Sal forest

To protect and conserve the Sal of Bangladesh, several measures should be considered.

Silvicultural systems must be improved to promote effective regeneration. At the same time, sustainable alternatives to forest-based livelihoods such as home gardening, forest product-based small cottage industry, beekeeping, and poultry farming may be explored. Technical and institutional education and training can also create alternative job opportunities. To formulate such management strategies, growth and yield information should be made available through an appropriate forest inventory that would allow computation of an annual allowable harvest that can be extracted from the Sal forests while still preserving the sustainability of the ecological, economical, and social values of these forests. Also, an accurate inventory of the encroached Sal forest is required to develop a viable land recovery plan. In addition, comprehensive protection measures must be developed to tackle the illicit activities such as forest land encroachment for agriculture, illegal tree felling, wood smuggling, and poaching of wildlife. There is an urgent necessity to strengthen the management of the Sal forest through recruiting well-trained and motivated forestry professionals, allocating sufficient budget, and developing infrastructures. The Sal forests must be brought under community reserves where local people can be made partners in conservation and management processes. Currently, there is no organized system of harvesting wood or wild medicinal and aromatic plants. An uncontrolled harvest often results in degradation of forest and quality of habitats. There is a need to formulate policies related to harvest of medicinal plants for the benefit of communities, thereby controlling excessive pressure on the forest land.

The future existence of the Sal forest in Bangladesh depends on the development and successful implementation of a sustainable management plan to protect and conserve these important resources. The government has attempted some initiatives to protect these important ecosystems but the sustainability of these resources could not be achieved due to a lack of sound management strategies. A sustainable management plan should be developed by involving all beneficiaries and stakeholders and should be effectively implemented to conserve these substantial ecosystems for present and future generations.

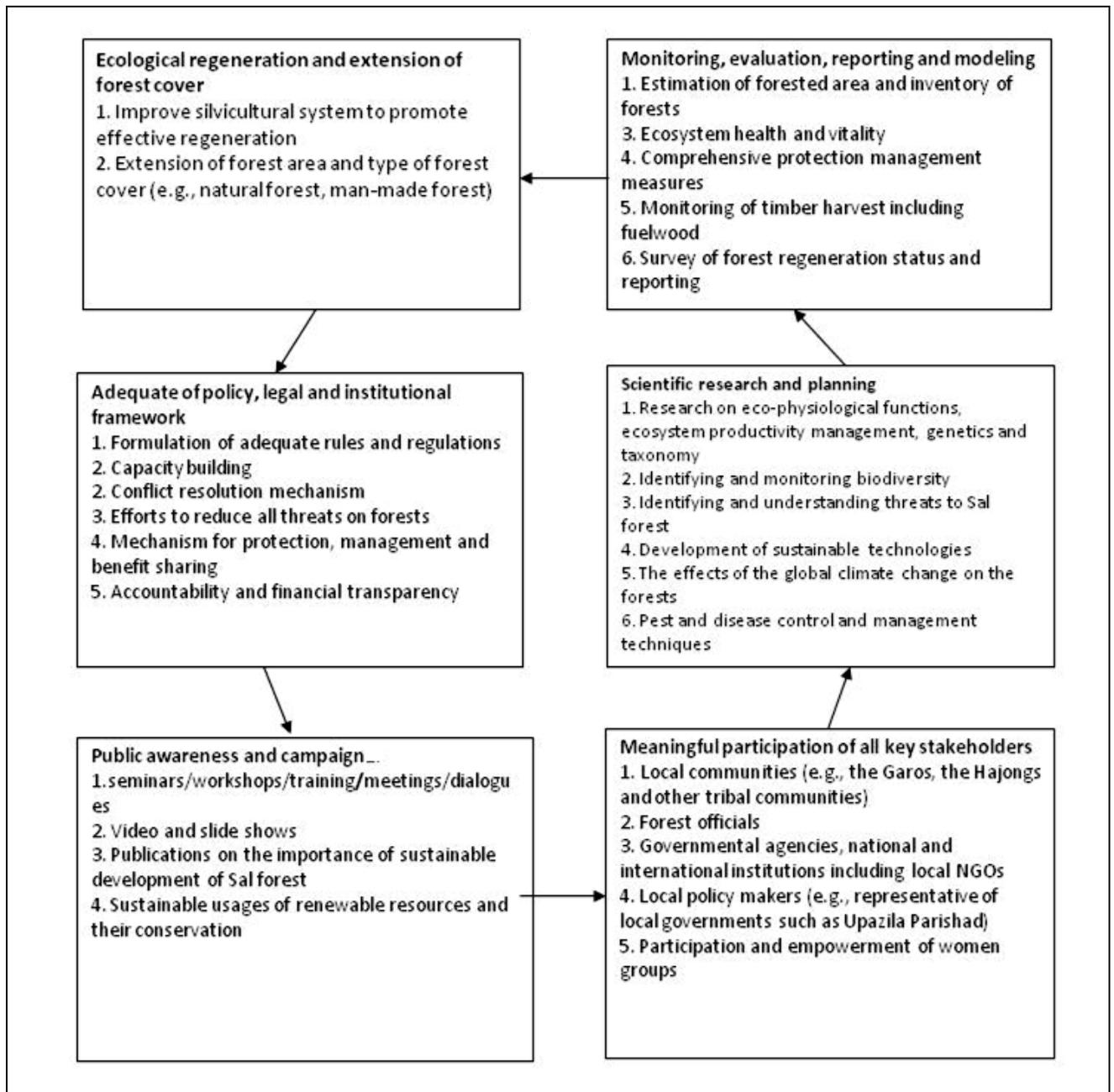


Fig. 3. The schematic presentation of a sustainable management plan for Sal forest ecosystem.

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