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INFESTATION OF IMPERATA CYLINDRICA L. AND ITS IMPACTS ON LOCAL COMMUNITIES IN SECONDARY FORESTS OF SITAKUNDA BOTANICAL GARDEN AND ECO-PARK, CHITTAGONG, BANGLADESH

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Abstract

Sungrass (Imperata cylindrica) infestation is reported to be detrimental to the biodiversity conservation in forest ecosystems, though it has some socio-economic importance. The present study investigated the infestation of Sungrass in Sitakunda Botanical Garden and Eco-park, Bangladesh as well as its contribution to local peoples' socio-economic condition. The study was conducted by reconnaissance survey, random quadrate survey, analyzing soil samples and social survey. Sungrass infested areas were categorized into ten landuse areas in the Eco-park. Soil pH was maximum (5.7) in exposed Sungrass fields, whereas minimum was found in eroded soil areas (4.2). The soil of Sungrass fields with horticultural plantation sites was represented by maximum organic matter (7.23%) whereas organic matter was minimum (3.02%) in the soil of Sungrass infested cactus plantation. Local people cultivate and harvest Sungrass for their livelihood, roofing, fodder and cultural needs. Seasonal variation exists in harvesting the Sungrass with a maximum (62%) in winter season (November to February). Farmers generate an average income of 4,800 BDT by selling Sungrass in the winter season. People opined that within the Sitakunda Botanical Garden and Eco-park area, Sungrass fields are increasing every year. This also leads to an increase of fire incidences in the forests of eco-park. Though the plant has some contribution to socio-economic conditions of local people, its infestation seems to be detrimental to the Sitakunda Botanical Garden and Eco-park of Bangladesh.

Keywords: *Imperata cylindrica; Ecosystem; Botanical garden; Eco-park; Sungrass; Sitakunda; Conservation*

Introduction

Tropical forests are unique ecosystems [1] and most of their biodiversity resides in herbs, shrubs, small trees to large ones in tropical forests [2]. Natural habitats must be protected and investigated to conserve their native biodiversity [3]. Being a part of the Indo – Myanmar region, Bangladesh is endowed with rich floral and faunal biodiversity [4]. Botanical Garden and Eco-park play an important role in conserving the biodiversity [5]. Bangladesh Forest Department attempted an ecological restoration of its denuded natural forests by establishing the first Eco-park at Sitakunda in the south-eastern Chittagong in 2000 [6]. One of the major aims of establishing Botanical Garden in Sitakunda, Chittagong is *ex-situ* conservation of biodiversity with other expected outputs such as improving site suitability, growth and yield performances of different species at various site conditions, future seed sources of threatened

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and rare species [7]. Sitakunda Botanical garden and Eco-Park are playing a vital role in *ex-situ* conservation of biodiversity in this region. A considerable number of medicinal plant species as well as other woody and non-woody species have been planted in this garden [8, 9]. But, now-a-days biodiversity of this park is in great threat due to over exploitation, illicit felling and fuel wood collection by the local people. Invasive behavior of *Imperata cylindrica* (Sungrass) growing in the open natural ecosystem of this park possesses mentionable threats. The sun grass is growing aggressively and thus occupying the spaces of native plant species in both natural and planted forest patches. Intentional fire hazards during dry season were also a great threat to the forest resources [10]. In the last few years, frequent fires are observed in this Eco-park mainly because of Sun grass (*Imperata cylindrica*) infestation and cultivation.

Imperata cylindrica L. (Poaceae family) is locally known as *Chhan*, *Kusha* (Cogon grass, Sungrass in English). It is a perennial grass species which tolerates a wide range of soil conditions, but appears to grow best in acidic soils (low pH), low fertility along with low organic matter and gradually found throughout the tropical and subtropical regions [11]. Brook [12] reported that the plant grows in association with mycorrhiza, which may help its competitiveness on unfertile soils. Sun grass spreads and dominates a wide range of disturbed soil by producing extensive rhizomes [11, 12]. In fire prone and low fertility forests, infestation by Sungrass is a major threat in achieving a good forest coverage and establishment of the plantations [13]. While Sungrass is tolerant of wide variations in soil fertility, organic matter and moisture, it grows well in relatively acid soils (pH 4.7) [14, 15]. Sungrass infested areas are difficult to convert to other vegetation [16]. An estimated 200 million ha are dominated by Sungrass in Asia, where infested areas are increasing at a rate of 150,000 ha annually [17]. On the other hand, in developing countries like Bangladesh poor people cultivate and collect Sungrass from nearby forests for preparing their house roof. It is a major thatching material that may also use as mulch, fodder and fuel. Through this, the plant contributes to the socio-economic conditions of the people living adjacent to forests. Sungrass cultivators harvest the plant each year and put fire after harvesting to enhance its germination and growth.

The natural forests predominantly non wood forest resources of Sitakunda eco – park was destructed in the last few years due to frequent fire occurrences induced by the local communities [18]. This fire causes serious problems by extending to nearby areas and burning other vegetation. A substantial area of Sitakunda Botanical garden and eco-park is infested rapidly by Sungrass and the infested area is increasing day by day. Though Sungrass infestation is detrimental to the Sitakunda Eco-park area, inventory focusing on *I. cylindrica* (Sungrass) infestation in the natural ecosystem and its role on surrounding localities is scarce for the eco-park. In the present study, an attempt has been made to assess *I. cylindrica* (Sungrass) infestation in the natural ecosystems along with its contribution on socio-economic condition of people living in surrounding localities of the Sitakunda Botanical Garden and Eco-park.

Materials and Methods

Study site

Sitakunda Botanical Garden and Eco-park lies between 22°36´0´´ - 22°38´20´´N latitude and 91°40´20´´ - 91°42´0´´E longitude [8]. It is about 35 km north from Chittagong city, 3 km away from Sitakunda Upazilla headquarter (Fig. 1) and about one kilometer east from the Dhaka – Chittagong highway [7]. It is situated at the north-western part of Chittagong district which comprises of the Chandranath Reserve Forest under the jurisdiction of Chittagong North Forest Division. The park area is under the jurisdiction of Southern Sitakunda Reserved Forest of Chittagong North Forest Division, Bangladesh. It was established in 2000 under Bangladesh Wildlife Preservation (Amendment) Act 1974. Before establishment the Eco-park, the area was under Chandranath block of Sitakunda Beat under Bariadhala Range of Chittagong North Forest Division [6, 7]. The Botanical Garden and Eco-park of Sitakunda comprises an area of about

808.38 ha, of which the Botanical Garden covers an area of 405 ha and the rest of 403.38 ha comprises the Eco-park [7].

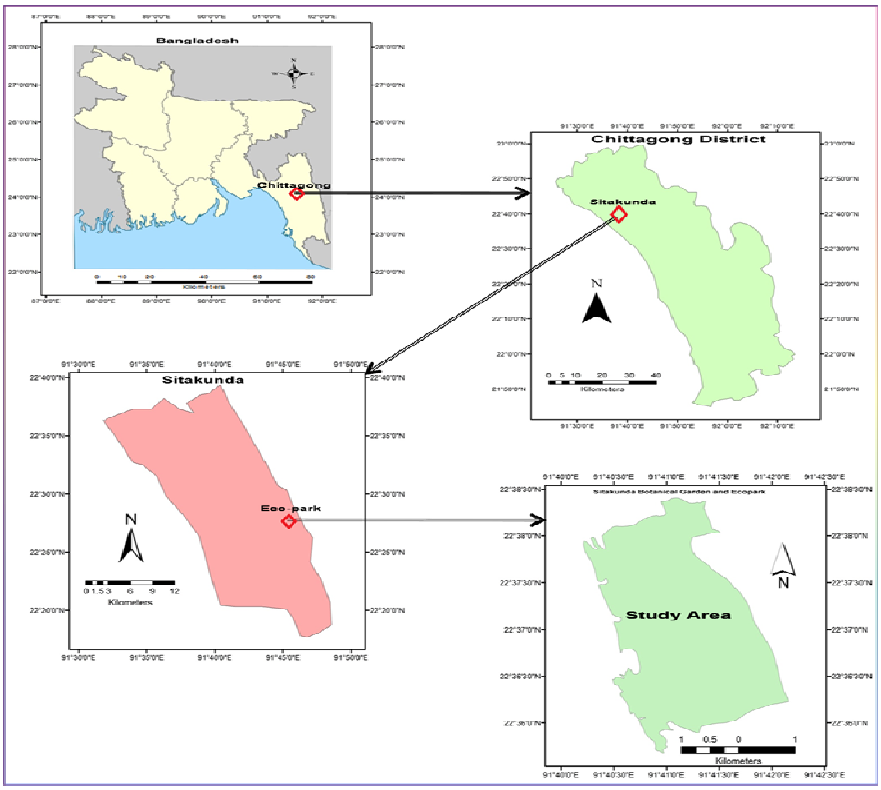

Fig. 1. Location of Sitakunda Botanical Garden and Eco-park in Chittagong district, Bangladesh

The original forest was semi – evergreen with rich floral diversity including various evergreen and deciduous species. The landscape has a broken topography comprised of very steep hills and valleys [8]. The park area lies under the tropical climatic zone and enjoys a moist tropical climate with a mean annual temperature of 29.6°C, 287.2 cm average annual rainfall, and 66.5% - 88.6% mean monthly humidity [7, 8]. The park area is composed of a good number of low, medium and high hills, numerous gullies, a few waterfalls and many streams that originate from the hills (Fig. 2), hills that are mainly part of Garo Hill Range [6, 7].

The methods of the study consist in collecting secondary informations, reconnaissance survey, field work, soil sample analysis, questionnaire survey, Focus Group Discussion (FGD) and finally data analysis [10, 13, 18].

Reconnaissance Survey

Field visits as well as formal discussion with the authority of Sitakunda Botanical Garden and Eco-park, Chittagong was done to have a preliminary idea about the topography, vegetation coverage and Sungrass infestation of the whole study area prior to the selection of the sampling procedure. Based on the information gathered from the reconnaissance survey, extensive field works and a socio-economic survey were conducted.

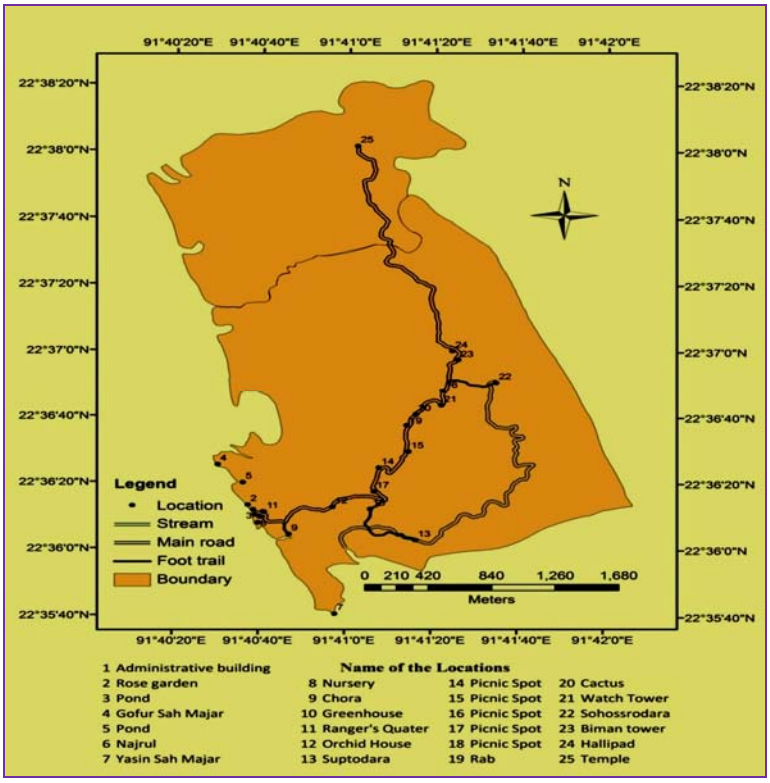

Fig. 2. Map showing the different sites of SitakundaBotanical Garden and Eco-park

Sampling Design

Seven field trips were conducted in three seasons during May 2013 to April 2014 to assess Sungrass infestation. To have an idea about Sungrass in the whole study area, a total of 40 sample plots of 50 cm × 50 cm in size were studied by random sampling method at 10 different sites, e.g. exposed area, medicinal species plantation, mixed tree plantation, Cactus plantation, ornamental plantation, *Acacia auriculiformis* plantation, horticulture plantation, natural forest patches, eroded hill slopes, degraded forests adjacent to the Sitakunda eco-park etc. All the sample plots were well demarcated with pegs. The height of Sungrass shoots in each plot was measured and recorded.

Analysis of soil samples

Soil pH and organic matter of Sungrass infested sites were measured. Soil samples were collected from all plots at 0 - 5 cm and 15 - 30 cm depth with a soil augur for measuring soil pH and organic matter, and preserved in polythene bags. Soil pH was analyzed in the Chemistry Laboratory of Institute of Forestry and Environmental Sciences Chittagong University (IFESCU), Bangladesh with an Orion digital pH meter. Weight machine was used to measure the weight of soil. Orion Soil organic carbon and organic matter were analyzed in Soil Research and Development Institute (SRDI) laboratory [28].

Preparation of the questionnaire, data collection and analysis

Information about the traditional uses and influence of the Sungrass were gathered through Focus Group Discussion (FGD). Focus Group Discussion (FGD) was conducted in the five surrounding villages of eco-park through the participation of local people. The survey was conducted in winter, summer and rainy season of the year 2013 and 2014.

Information about the impacts of Sungrass on eco-tourism and biodiversity of the park were collected through questionnaire survey and field observations. The questionnaire was

designed as semi-structured and pretested to fit in the field. Both local and foreign visitors, local communities and local businessmen of the study areas have been targeted for interviewed in this study. 40 local people, 15 local businessmen, 5 officials and 50 eco-tourists (age ≥ 10 years) were interviewed in the study area for collection of field data and information about their perception on Sungrass infestation. In total 140 local households were surveyed to gather the information about Sungrass collection from the Eco-park. All the respondents were selected randomly**.** Field survey (tourist survey) was conducted during both non-holidays and holidays especially in Friday and Saturday. The period of the survey was from 9.30 am to 1.30 pm and 2.30pm to 5.30 pm. All information (qualitative and quantitative) was sorted carefully, analyzed, and present scientifically in form of tables and graphs [10, 13].

Results

Imperata cylindrica (Sungrass) infestation in natural ecosystems of Sitakunda eco-park

Sungrass was recorded from thirty locations of the park area. The Sungrass growing areas were categorized into ten infested sites. Organic matter (%) and pH in the soil of Sungrass infested areas varied from location to location within the eco-park. Maximum pH (5.7) was found in the barren hills and the lowest was (4.2) in the eroded areas where Sungrass infestation occurs. Assessment of organic matter revealed that Sungrass infested area inside horticulture plantation site was represented by maximum (7.23%) organic matter, where minimum (3.02%) organic matter was found for Sungrass infested areas within cactus plantation (Table 1).

Table 1. Soil pH and organic matter (%) of different sun grass infested sites

SL. No.	Sun grass infested site	Soil pH	Organic carbon (%)	Organic matter (%)
01.	Natural forest patch	4.6	2.13	3.67
02.	Exposed area	**5.7**	3.79	6.55
03.	Medicinal species plantation	4.7	2.52	4.33
04.	Mixed tree plantation	4.9	2.08	3.57
05.	Cactus plantation	5.2	**1.76**	**3.02**
06.	Eroded hill slopes	5.4	2.07	3.56
07.	Ornamental plantation	4.7	2.76	4.76
08.	Horticulture plantation site	4.9	**4.19**	**7.23**
09.	*Acacia auriculiformis* plantation	5.4	3.32	5.72
10.	Encroached area	**4.2**	2.95	5.09

Infestation of Sungrass in the natural ecosystem of the study area varied widely. Height of Sungrass shoots in various infested sites show wide variations (0.6m – 1.7m). Maximum height (1.7 m) of Sungrass was found in cactus plantation and the lowest height (0.6m) was found in the exposed areas (Fig. 3).

Frequent fires in the Eco-park area

Intentional fire during dry season is one of the major threats to this garden as it degrades the soil by burning the soil microorganisms, wildlife habitat and regenerated seedlings. It was found that, in 2012 and 2013 fire occurrences were severe and burnt about 72 ha areas of the study area. In 2013 and 2014, the fire burnt areas were about 101 ha (Table 2).

Table 2. Fire occurrences in the study area
(Source: Forest office, Sitakunda Eco-park, Chittagong, Bangladesh)

SL. No.	Year	Fire damages in ha (approx.)
01.	2009-2010	31
02.	2010-2011	37
03.	2011-2012	44
04.	2012-2013	72
05.	2013-2014	101

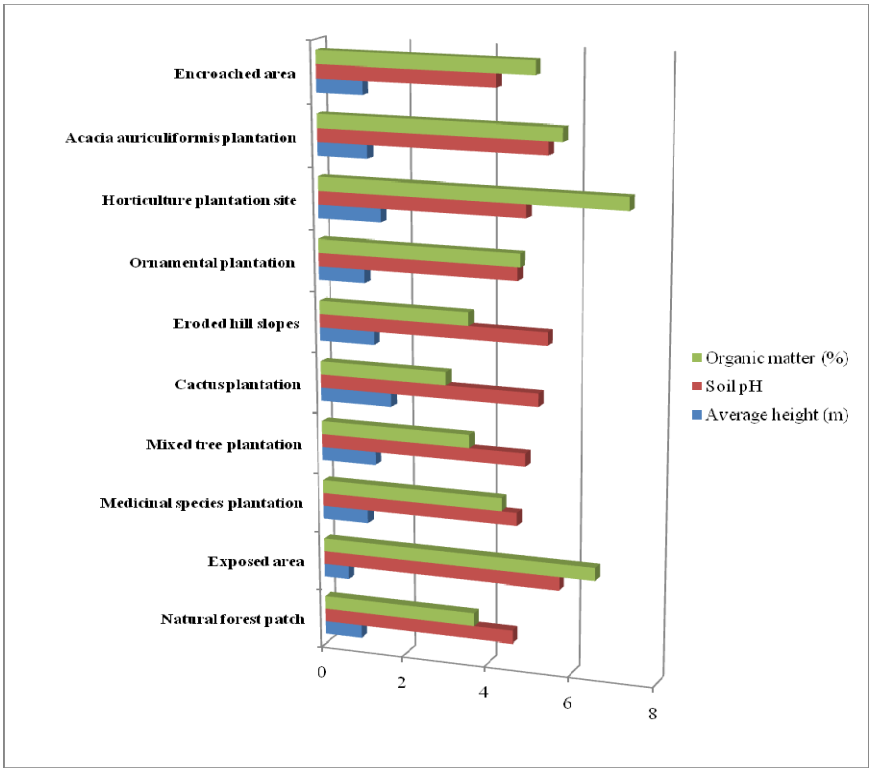

Fig. 3. Average height of *Imperata cylindrica* (sungrass) shoots at different soil pH and organic matter (%) in the sungrass infested sites.

Forest fires in the Sungrass infested areas are common scenarios during dry season when the litters on the forest floors are very flammable. Sungrass fires spread rapidly, with large and vigorous flames. Such intense grassland fire easily escapes control and destructs the forested land from all directions. Careless use of fire by the eco-tourists in the Botanical Garden and Eco-park area is another reason of fire occurrence.

However, the major reason is the local peoples' careless ignition and burning of Sungrass fields after harvesting the plant. Hence, in the last 5-6 years, frequent fires were observed in the Eco-park because of the increased Sungrass (*I. cylindrica*) cultivation and careless burning of the cultivation field after harvesting it. Other than these, more fire occurrences were reported by the local people during "Shib Choturdashy" festival of Hindu religion. During this festival, a huge number of pilgrims from various regions of the country visit the old Hindu temple at the highest peak of Sitakunda hills once a year of about three days in April and careless use of fire (like smoking, cooking etc.) within the region and nearby areas of the eco-park by the pilgrims causes fire hazards. Fires gradually invade the forest burning mainly the litter layers on the forest floor and slowly progressing along the surface of the forest ground. The present study revealed that the area of Sungrass fields in the Eco-park is increasing day by day and with it the number of fire hazards (Fig. 4).

Available Non- wood Forest Products (NTFPs) in the study area and collection of Sungrass

The forest area consist of a large amount of bamboo, cane, patipata/murta, medicinal plants, and fuel wood. From the present study it is confirmed that, local people collect bamboo and Sungrass from the park area more than other non wood resources. The dependency of local communities on Sungrass along with other NTFPs and their collection from the Eco-park were determined by local forest people's perception. This dependency varied from village to village,

community to community, season to season, household to household even person to person. Three types of Non- timber Forest Products (Bamboo, Sungrass and Fuel wood) were more harvested (Fig. 5) and approximate 71% of surrounding households engaged in non wood forest products collection in this ecologically important forest.

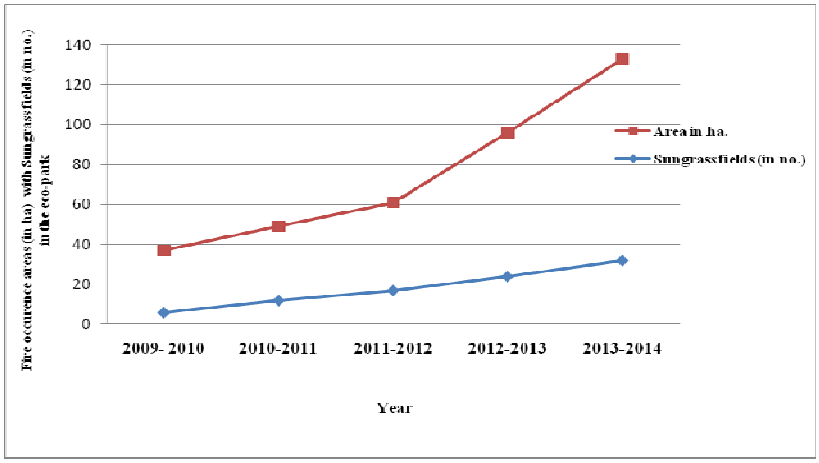

Fig. 4. Sun grass infestation areas with increasing fire occurrences in the park area during last six years

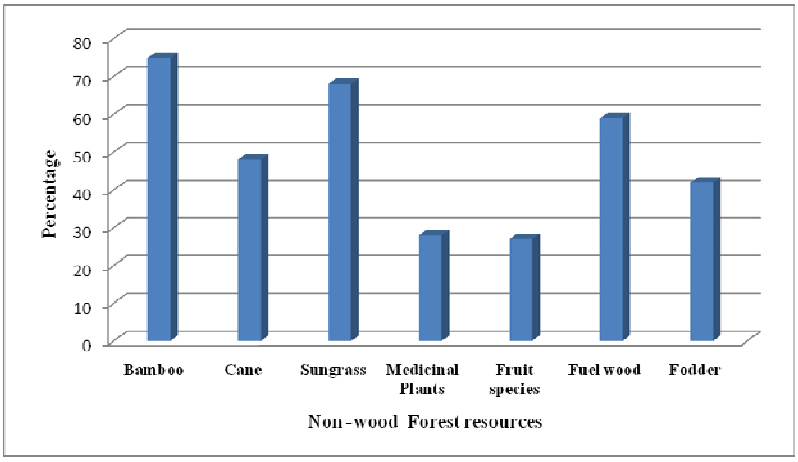

Fig. 5. Percentage of households involved in various non–wood forest resources collection.

Impact of Imperata cylindrica (Sungrass) on local communities

The focused group discussion and questionnaire survey revealed that Sungrass shoots have a substantial influence on local communities for livelihood, food and fodder. Focused Group Discussions (FGDs) in the three surrounding villages involving participants from the local communities (Bengali and Tribal people) revealed that more than 57% of the fodder is composed of Sungrass. Thatching materials of 62% of the participants were met by the Sungrass extracted from the Sitakunda Botanical Garden and Eco-park.

Seasons in Sungrass (I. cylindrica) collection

The dependency of local people on sun grass in the park area was determined by the interviewees' perception. Dependency varied from household to household and season to season. The survey revealed that a total of 68% households were involved in sungrass collection from the Sitakunda Eco-park. Their dependency was high during the winter season (November

–February), moderate in the summer season (March – April) and minimum in the rainy season (May-August) (Fig. 6). The present study revealed that 62% of the households collect Sungrass during the winter, 27% people collect during the summer and 11% households extract it in the rainy season**.** The study also revealed that 17% of the people collect Sungrass during both the summer and winter season.

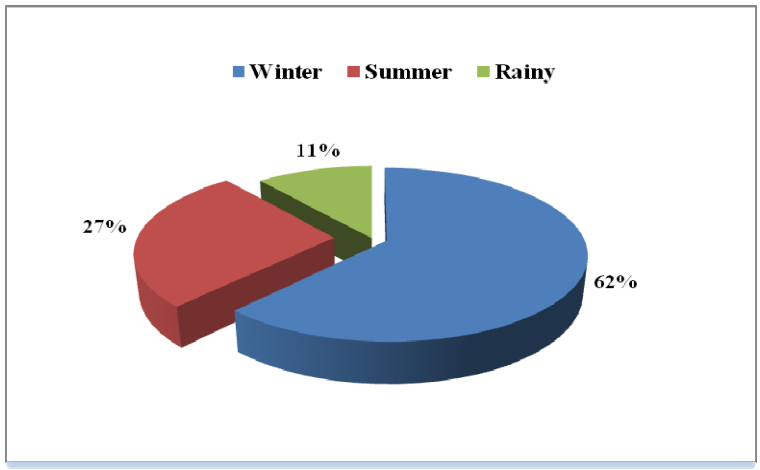

Fig. 6. Dependency of households (%) on Sun grass in various seasons.

Purposes of Sungrass (I. cylindrica) collection

This Eco-park is surrounded by the settlements of poor Bengali and Tripura community. They collect Sungrass mainly for thatching materials (62%), fodder (20%) and religious purposes (5%) (Fig.7). Some people use sungrass as a component of their houses ceiling (4%). The study also revealed that a substantial number of local people extract and use Sungrass for their miscellaneous domestic purposes (9%), i.e. mulch, fuel, fence etc. It is also used as fire wood by the local households. Sungrass shoots, locally known as *kushas*, are used for religious purposes by the local Hindu communities.

Income from Sun grass (I. cylindrica)

The results of the study depicted that local people sell substantial amounts of Sungrass along with using it as a thatching material, fodder and religious purposes. Sungrass selling is an important cash income source for some of the local people. Local people harvest Sungrass from November to February each year along with other NTFPs (Fig. 8). After drying the harvested Sungrass in the field, they bind them into bundle and sell to the neighbors or local markets. From the present study it was determined that a total of 14% of the people earned livelihood by selling sun grass in the local market. The respondents earn an average BDT 4,800 ($61.5 USD) per year. This amount of money provides support to their livelihood.

Impact of Sungrass infestation on Eco-tourism Development

Botanical Garden and Eco-Park area is enriching day by day through artificial plantation and infrastructure development. The present study revealed that tourists visited the park area for different kind of recreational activities. Among the recreational activities, sight visit (28%) and nature study (26%) were the prime object of the tourists. Only 19% of the total tourists come to the eco-park for religious purpose. But most of the tourists (52%) said that they were poorly satisfied due to excessive infestation of Sungrass in the natural forest floors and they were not feeling secure in the park area. There were very few facilities for enjoying the natural view of eco-park due to excessive Sungrass infestation. Only 21% of total tourists said that they have enjoyed aesthetic beauty of the park area and they had no headache regarding the Sungrass infestation in the park (Fig. 9).

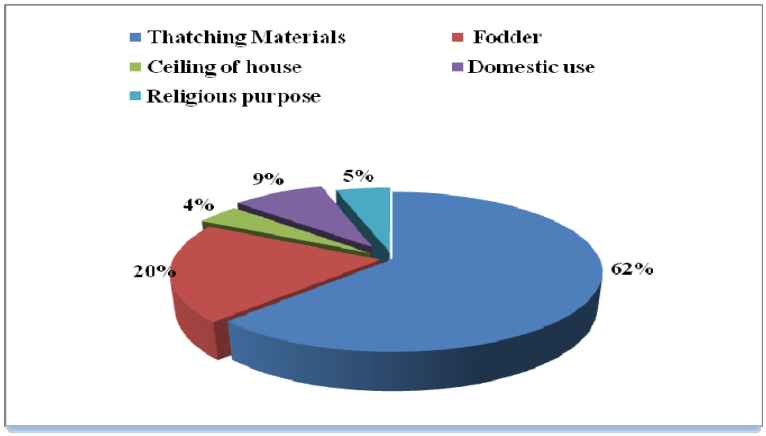

Fig. 7. Sun grass uses by local communities (%)

Fig. 8. Local people collect sungrass and bamboo from Sitakunda Eco-park.

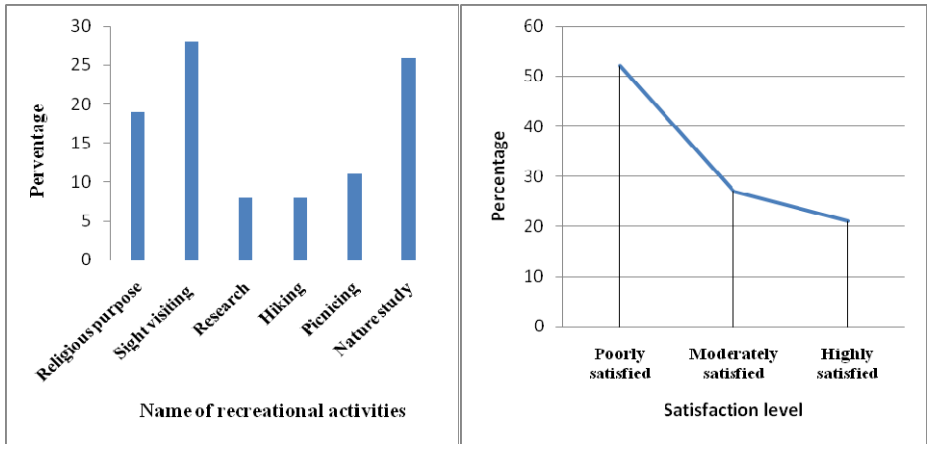

Fig. 9. Visiting purpose (%) (left) and levels of satisfaction (%) of the eco-tourists in Sitakunda Botanical Garden and Eco-park, Bangladesh.

Impact of Sungrass infestation on Biodiversity

Sitakunda Eco-park is the first eco-park of Bangladesh, with its ecosystem a secondary one. Most of the forest areas in this eco-park are degraded. Its primary vegetation, mainly NTFPs, has passed under severe deforestation, degradation and destruction due to biotic interferences and severe fire hazards. Recently most of the valley portions and plain lands of this eco-park are converted into betel leaf farms (Fig. 10). Excessive harvesting of forest products (such as Sungrass, bamboo, cane and fuel wood) can obviously modify species composition, diversity and wild vegetation of the Botanical Garden.

The present study revealed that Sungrass infestation in the secondary degraded forests has a negative impact on wildlife and biodiversity. During the study, it was found that many portions of the park area were burnt by intentional fires which caused a rapid infestation with Sungrass and mortality of seedlings, undergrowth, micro-organisms etc. The intensity of fire hazards in the park area was so high that in many areas wildlife species lost their natural habitats (Fig. 10). Many native birds lost their nests and reptiles run away from their own habitat during fire. Many soil dwelling animals have died and some vertebrates have become rare due to fire occurrences**.** Most of the wildlife is not habituated to survive in the Sungrass infested sites. Local people and some officials opined that, they do not see native birds and reptiles now in the Botanical Garden. As a result, wildlife habitat and species diversity in the Sitakunda Eco-park area are being threatened severely.

Fig. 10. A betel leaf farm (left)**,** an exposed sungrass field (middle) and dense sungrass along a foot trail (right) within the Sitakunda eco-park area.

Discussions

Sungrass infestation is a crucial problem in the study area that increases fire hazards during dry season. Sungrass shoots grow best in soils with low fertility and low organic matter [11]. So, sungrass infested areas in the eco-park indicates degraded soil with low fertility. Sungrass reduces the soil moisture and make the soil hard, thus hamper the regeneration of plant species and forest coverage [13]. As a result, sungrass infestation has become a common threat to biodiversity. Frequent intentional fire occurrences in previous years were seen by local communities during the dry season in the sungrass infested areas. Frequent fire in the park area caused less undergrowth and ground vegetation in the natural and planted forest patches. Fire protection is the major threat for Eco-park. For controlling fire, there exists no logistic support in the eco-park. Inadequate water supply and less supporting staff are the basic causes for extreme fire damage. During dry season, fire hazards cause the huge loss of native biodiversity. Most wildfires in the park area are caused by local communities. Local people are responsible for most soil disturbances and fire hazards inside the park. As they don't have other alternatives, they are engaged in collecting sungrass as well as non wood products from the eco-park everyday which leads to the slow destruction of the area. These disturbances are interrupting the ecological restoration of the Sitakunda Botanical Garden and Eco-park for the

established reason. Eco-tourists should be careful to use fire in the core zones. Visitors, who visit the park for the religious purpose, should also be conscious about fire occurrences.

Though Sungrass is native to South-east Asia, it is found throughout the world and established on over 500 million hectares worldwide [11, 19]. Sungrass is most wide spread in Asia, gradually in northern India, stretched into Nepal where over 70 million acres are reported as infested [20]. Information about sungrass infestation of Sitakunda eco-park as well as Bangladesh is scarce. Sungrass infestation is a crucial problem to conserve biodiversity in the study area as well as all over the country. Sungrass is found at the core zones of a good number of Wildlife Sanctuaries (WS) in Bangladesh i.e., Chunati WS, Dudpukuria - Dhopachari WS, Fashiakhali WS, Rema-Kalenga WS etc [13, 21, 22, 23]. The present study revealed that approximately 250 - 285 hectares area of Sitakunda Eco-park is infested through Sungrass. Further study could also be carried out to assess the total Sungrass infested areas in the various protected forests of Bangladesh and the urgency to control Sungrass infestation to restore native biodiversity.

The present study revealed that most of the Sungrass fields were found in the core zones and a few number of Sungrass infested sites were found in the buffer zones of the garden. Similarly, Sungrass infestation in the core zones of Chunati Wildlife Sanctuary and Fashiakhali Wildlife Sanctuary of Bangladesh were reported by Hossain and co-researcher [13] and *Uddin et al.* [22] respectively. *Toma et al.* [24] found a number of degraded vegetation, mainly Sungrass (*Imperata cylindrica*) infested fields in the eastern part of Kutai Regency, East Kalimantan, Indonesia.

The study area is very much infested by Sungrass and a huge number of local people depend on sun grass collection for their daily needs. The present study revealed that approximately 68% local households are involved in Sungrass collection from the Sitakunda Eco-park which was higher than of Das (2014) [23]. A study conducted by Das [23] in 4 beats (Rema, Kalenga, Chanbari and Rashidpur) of Habiganj-2 forest range in Bangladesh reported 7 - 20% households were involved in sun grass collection. The present investigation also indicating that three types of non-wood plant resources (Bamboo, Sungrass and fuel wood) were more harvested by the local people and approximate 71% households involved in NTFPs collection from the Eco-park area which is less than Das [23] conducted in the north- eastern region of Bangladesh. Das [23] reported that four types of NTFPs (fuel wood, bamboo, fodder and medicinal plants) were more harvested by the forest people from four beats of Habiganj-2 range, Sylhet Forest Division in Bangladesh area and approximate 75% households involved in NTFPs collection activities.

A study was conducted by Nath and co-researcher [25] in the same study area reported that 32% families were dependent on the forests of Sitakunda Botanical Garden and Eco-Park of which most of them were in poorer strata of the community and only 17% families were getting benefits, maximum were seasonal which was less than the present study. The present study indicating that the dependency of people (71%) on the Eco-park is increasing day by day in order for them to fulfilling their daily needs. As a result, natural resources of this Eco-park are decreasing continuously.

Nath and co-researcher [25] also reported that only 12% of the total manpower in the garden and eco-park is employed permanently from the local community. The maximum pay for an employment day is an insufficient 80.00 BDT per day which was not also paid regularly. Thus, local people were not interested to engage themselves as daily laborers. From the present study, it is found that most of the local people work as daily laborers in the nearby market. Some local people have floating businesses and some of them work in the agricultural fields, betel leaf farms etc. Local people were also engaged in agro forestation in the core zones of the park and planting betel leaf, cucurbits along with fruits, chilly etc. Some trees were affected by fire as visitors in the study area unintentionally started fires by throwing cigarettes. Fewer trees were found in that area. But tall Sungrass plants were found in an even greater number in the

areas affected by fire. Local people collect these tall Sungrass as fuel wood. It was observed that during the fuel wood collection, they cut saplings also and collect them to sell in the market.

Though the collection of Sungrass along with other non-wood resources from the park area is not their main job, these resources make a vital contribution to their livelihoods. Sungrass and other natural resources provide them extra income and sometimes they are earning more money from these resources in comparison to their main job. Local people do not engage in conservation activities as they have no ownership for the Eco-park area. It is necessary to ensure the participation of local people in decision making, different plantation activities, during selection of species etc. This could improve the condition of the status of regeneration and tree species diversity of the study area.

Community based forestry programs might be a better idea for upgrading the present condition of the status of regeneration and tree species diversity as well as the economic condition of the local people. Through this approach local people would be more conscious regarding the protection of the area. Awareness raising and better understanding among the local people and the eco-park authority could help to minimize the disturbances in the study area. Forest Department should take proper steps to protect natural regeneration, control fire occurrences and provide various forest based employment opportunities to the local people for mitigating their dependency on forest resources. Local people of the study area entering the park to collect fuel wood, Sungrass, timber etc should be prohibited in the regeneration period and government may provide some incentives through money, small loan, training etc to help local people in managing alternative income generating programs. Forest Department may recruit local people around the park area as Forest guard, Field man, Garden assistant, MLSS etc to reduce their dependency on forest resources.

Warm season perennial grass species like *I. cylindrica* (Sungrass*),* which grows well in a wide range of soil conditions, are a great threat to the natural ecosystems along with other alien invasive species [26-27]. Similarly, safety and security are not well developed in this park. Safety and security should be well developed in this park which is very important for the attraction of the tourists and local people around the park area may be recruited as tourist guide to create employment opportunities for them.

Conclusion

Sitakunda Botanical Garden and Eco-park is greatly infested by Sungrass (*Imperata cylindrica)*. A substantial number of people are also dependent on Sungrass cultivation and extraction for seasonal livelihood, roofing the house, fodder and cultural needs. During the field work, few local people opined that the infestation is increasing year by year due to Sungrass harvesters' encroachment (clearing and burning). Sungrass infestation in the park area can degrade the habitat suitability for many species. Intentional fires that spread from Sungrass fields will cause further reduction in regeneration, undergrowth population, micro-organism activity etc. It is right time to take measures in order to control sun grass cultivation and fire hazards inside the eco-park area for conservation of its biodiversity as well as natural ecosystem.

Sustainable forest management, education and awareness among the local people are the important factors for decreasing Sungrass infestation in the eco-park area. Local people that dependent fully or partially on Sungrass for varies purposes may be provided with better alternative income generating incentives and employments in order to reduce their dependency on sun grass. Local and international eco-tourists visit this Botanical garden for recreational, research and religious purposes. They should be conscious about fire hazards. Forest Department should also aware to control fire occurrences and protect natural regeneration. Awareness regarding fire hazards of the Sitakunda Botanical Garden and Eco-park will also

help in conservation of biodiversity and natural resources of the study area. The present result is the preliminary finding of Sungrass infestation on natural and secondary forest ecosystems of Sitakunda Eco-park. Further studies, research and monitoring are also needed to record all the infested sites, and impact of *Imperata cylindrica* on local communities and biodiversity of Sitakunda Botanical Garden and Eco-park.

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