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Exotic Plants and their Usage by Local Communities in the Sitakunda Botanical Garden and Eco-Park, Chittagong, Bangladesh

Shourav Dutta*, Hossain MK, Akhter Hossain M and Pinaki Chowdhury

Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong, Bangladesh

Abstract

The study was carried out to assess the occurrence, invasion and usage of exotic plant species in the natural ecosystem of Sitakunda Botanical Garden and Eco-park, Chittagong, Bangladesh through transect and random sampling and Focused Group Discussion (FGD) during August 2013 to April 2014. A total of 103 exotic plant species (99 species of angiosperms and 4 gymnosperms) belonging to 90 genera and 43 families were recorded through transect method from the study area. Among the exotics, tree species constitute the major category (46 species, 21 families) followed by shrubs (33 species, 18 families), herbs (21 species, 17 families) and climbers (3 species, 3 families). Mimosaceae family was represented by maximum (9) exotic plant species followed by Caesalpiniaceae (8), Myrtaceae (8) and Malvaceae (7). Most of the exotic plants were introduced in the eco-park after its establishment. Exotic tree species are given priority as the dominant plantation species in the eco-park area because of their short rotation, wider adaptability and faster growth. A total of 74 tree species (52 native and 22 exotic) belonging to 33 families were recorded through random sampling method in the eco-park. Number of both exotic and native tree species in hill top, mid hill and hill bottom varied simultaneously. Density of exotic trees were found maximum (366.6/ha) in the hill bottom. *Holarrhena antidysenterica* (14.77) and *Stereospermum colais* (14.53) were the two native tree species that showed maximum Importance Value Index (IVI). Besides, two exotics that showed maximum IVI were *Xylia xylocarpa* (10.05) and *Psidium guajava* (9.15). The enumerated exotic plant species were categorized under six different traditional use categories according to their habit form (tree, shrub, herb and climber). The study revealed 39 exotic species used for timber purpose indicates their prominent economic potentiality. Moreover, local communities extracting exotic plants for meeting their needs of fuel, housing implements, livelihoods etc. Control of the exotics in future plantation programs need to be considered and available native plants should give priority to ensure ex-situ conservation of the Botanical Garden and Eco-park.

Keywords: Exotic plants; Eco-park; Botanical garden

Introduction

Bangladesh, located in the north eastern part of South Asia with a geographical coverage of 14.76 m ha is exceptionally endowed with a huge variety of flora and fauna due to its unique geophysical location, and possesses a rich biological heritage of flowering plants, mammals, birds, reptiles, amphibians and fishes [1-3]. But, loss of biodiversity was significant in the natural forests of Bangladesh during the past four decades due to population pressure, over extraction, anthropogenic disturbances, unscientific management and lack of conservation initiatives [4]. One of the major management objectives of hill forests of Bangladesh was to replace the heterogeneous natural forests by the plantations of valuable timber species. To meet the acute shortage of timber and fuel wood in Bangladesh, Bangladesh Forest Department introduced fast growing tree species as priority basis. Some exotic tree species were widely planted in the natural ecosystems replacing the native vegetation; as a result the exotic tree species became dominant in the plantation forests and homesteads [5]. Like many other countries, Bangladesh has a long history of plant introduction from different countries or geographic regions of the world and most of the plants have brought by settlers, invaders, seamen and traders [6]. Teak (*Tectona grandis*) was first introduced by the British in hill forests of present Bangladesh in 1871 [5]. A number of exotic plant species were first introduced in garden as ornamental plants that later on aggressively established elsewhere [7].

Sitakunda Eco-park, the first Eco-park in Bangladesh, was established at Chandranath hills and its surrounding areas of Sitakunda upazilla of Chittagong district in 2000 in order to preserve and develop the gene pool of various indigenous and exotic plant species through intensive management [8,9]. Bangladesh Forest Department manages this eco-park. Plantations of short rotation species, mainly of *Eucalyptus* spp. and *Acacia auriculiformis*, were raised in the Botanical Garden till 1999. The Botanical Garden and Eco-Park area was the remnant of tropical semi-evergreen forests rich with floral composition, e.g. Rahman and Uddin [10] recorded 203 species belonging to 154 genera and 54 families from the entire Sitakunda Reserve Forest. Alam [8] recorded 55 shrubs and 62 herbs on the hills of Sitakunda Botanical Garden and Eco-park area. But, no inventory on focusing exotic plant species of the eco-park and their role in surrounding localities has so far been found, though the invasion of exotics is becoming a concern for the park. To prepare baseline information on exotic plant species and to help development of planning and managerial activities of the Eco-park, it is necessary to assess exotic plant species of the eco-park area. In the present study, an attempt has been made to assess the occurrence of exotic plants along with their influence in the natural ecosystem and surrounding localities of the Sitakunda Botanical Garden and Eco-park. Categorizing the recorded exotic plants based on their habit form and use was another aim of the study.

***Corresponding author:** Shourav Dutta, Institute of Forestry and Environmental Sciences, University of Chittagong, Bangladesh; Tel: 031-716552; E-mail: Shourav.forestry@gmail.com

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Material and Methods

Study site

Sitakunda Botanical Garden and Eco-park lies between 22°36′ - 22°39′N latitude and 91°40′ - 91°42′E longitude. 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. It is about 35 km north from Chittagong city, 3 km far away from Sitakunda Upazilla head quarter and about one kilometer east from the Dhaka – Chittagong highway [8]. The park area is under the 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 area was under Chandranath block of Sitakunda Beat under Bariadhala Range of Chittagong North Forest Division [8,11].

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 rest of the 403.38 ha area is under the eco-park [8]. The park area is composed of a good number of low, medium and high hills, numerous gullies, a few waterfalls and many streams originated from the hills and these hills are mainly the part of Garo Hill Range [8,11]. The original forest was semi evergreen with high floral diversity including various evergreen and deciduous species. The landscape has a broken topography comprising of very steep hills and valleys [12]. The park area lies under the tropical climatic zone and enjoys moist tropical climate of 29.6°C mean annual temperature, 287.2 cm average annual rainfall, and 66.5% - 88.6% mean monthly humidity [8,11,12].

Methods

Exotic plant species in Sitakunda Botanical Garden and Eco-park were studied by transect method during August 2013 to April 2014. Transect walks were made along the foot trails that passed across the whole study area. All the exotic plant species (herbs, shrubs, trees and climbers) were recorded and tagged in the field. Fertile plant parts of the unknown tree species were collected to prepare herbarium in order to facilitate their identification. The herbaria were identified consulting different flora [13-16].

A total of 36 sample plots of 10 m × 10 m in size were selected in the whole study area by random sampling method. Among 36 sample plots, the hill top, mid hill and the valley were represented by 12 plots each. Quadrats were distributed to each of the four aspects (southern, northern, eastern and western) evenly at the hill top, mid hill and valley of hill. All the plots were well demarcated by marking their corners with pegs and then all the trees (native and exotic) in each plot were identified and recorded. Individuals of each tree species having dbh of ≥5 cm at breast height (1.3 m) were counted and recorded.

Identified plant samples were arranged taxonomically and categorized according to their habit form. The relative density, relative frequency, relative dominance and Importance Value Index (IVI) were calculated following the methods of Shukla and Chandal [17].

$$\text{Density of a species} = \frac{\text{Total no.of individuals of a species in all the quadrats}}{\text{Total no. of quadrats studied}}$$

$$\text{Relative density} = \frac{\text{Total no. of individuals of the species}}{\text{Total no. of individuals of all the species}} \times 100$$

$$\text{Frequency of a species} = \frac{\text{Total no. of individuals of quadrats in which the species occurs}}{\text{Total no. of quadrats studied}}$$

$$\text{Relative frequency} = \frac{\text{Frequency of one species}}{\text{Total frequency}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Basal area of one species}}{\text{Total basal}} \times 100$$

IVI = Relative density + Relative frequency + Relative dominance

Information about the traditional uses and influence of the recorded exotics were gathered through Focused Group Discussion (FGD) involving local communities living around the surrounding areas of the botanical garden. Consultation was also made with the Encyclopedia of Flora and Fauna of Bangladesh [14,16] to better assess the use of the recorded plants. Along with the timber producing exotic plants, many medicinal, fuel wood, fiber yielding, ornamental and shade bearing exotic plant species were recorded from the eco-park and thus, categorized into six categories (timber, food or fodder, medicine, ornamental, fuel wood and miscellaneous).

Results

Exotic species composition and their habit form

The present study recorded a total of 103 exotic plant species belonging to 90 genera and 43 families from Sitakunda Botanical Garden and Eco-park, Chittagong. All the exotic plant species were categorized based on habit form and classified under genus and family (Table 1). The species botanical name, family, local name, habit form and their uses are provided in Table 2.

Among the 103 exotic plant species, trees constitute the major category (46 species) and occupying 45% of all the recorded exotic species followed by shrubs (32%), herbs (20%) and climbers (3%). The abundance of species belonging to various families shows variation, where, 49% species are represented by 8 dominant families and rest of the 51% species by 35 families (Figure 1). Among the dominant families, Mimosaceae contains maximum number of species (9 species) followed by Caesalpiniaceae (8 species), Myrtaceae (8 species), Malvaceae (7 species), Apocynaceae (5 species), Fabaceae (5 species), Annonaceae (4 species) and Euphorbiaceae (4 species).

The study recorded 46 exotic tree species under 40 genera and 21 families from Sitakunda Botanical garden and Eco-park, where Mimosaceae was represented by maximum 8 tree species followed by Myrtaceae (6 species) and Caesalpiniaceae (5 species). *Acacia auriculiformis* (Akashmoni), *Acacia mangium* (Mangium), *Eucalyptus camaldulensis* (Eucalypts), *Melaleuca leucodendron* (Melaleuca) and *Tectona grandis* (Shegun) were very common since they were used as major plantation tree species in Sitakunda eco-park. These exotic tree species are gradually replacing native tree species of the park area because of their wider adaptability, faster growth rate and easy

Sl. No.	Plant Category	Species no.	Genus no.	Family no.	Species %
01.	Tree	46	40	21	45
02.	Shrub	33	27	18	32
03.	Herb	21	20	17	20
04.	Climber	3	3	3	3

Table 1: Exotic plant species recorded from Sitakunda Botanical Garden and Eco-park.

Scientific name	Family	Local name	Habit	Uses
Acacia auriculiformis A. Cunn. *ex*. Benth	Mimosaceae	Akashmoni	t*	F, N, T**
Acacia catechu (L. f.) Willd	Mimosaceae	Khair	t	F, N, T
Acacia mangium Willd	Mimosaceae	Mangium	t	F, N, T
Achras zapota L.	Sapotaceae	Sofeda	t	F, M, N
Albizia richardiana King & Prain	Mimosaceae	Raj Koroi	t	F, N, T
Aloe vera (L.) Burm. f.	Liliaceae	Greeta kumari	h	Fd, M
Alstonia macrophylla G. Don	Apocynaceae	Sri Lankan Chatian	t	F, N, T
Amorphophallus campanulatus (Roxb.) Bl. *ex* Dane.	Araceae	Ol kochu	h	Fd, N
Anacardium occidentale L.	Anacardiaceae	Kaju Badam	t	Fd, N, T
Annona reticulata L.	Annonaceae	Atah	s	Fd, M, N
Annona squamosa L.	Annonaceae	Sarifa	s	Fd, M, N
Antigonon leptopus Hook. & Arn.	Polygonaceae	Ananta lata	c	N
Araucaria columnaris (Frost. F.) Hook.	Araucariaceae	X-mass tree	t	N
Artabotrys odoratissimus R. Br.	Annonaceae	Katali champa	h	O
Averrhoa bilimbi L.	Oxalidaceae	Bilambi	s	F, Fd, M, N
Averrhoa carambola L.	Oxalidaceae	Kamranga	s	Fd, M
Bauhinia malabarica Roxb.	Caesalpiniaceae	Kanchan	s	N, O
Bombax ceiba L.	Bombacaceae	Simul tula	t	N, T
Borassus flabellifer L.	Arecaceae	Tal	t	Fd, M, N, T
Bougainvillea spectabilis willd.	Nyctaginaceae	Bagan bilash	s	N, O
Bryophyllum pinnatum (Lam.) Oken.	Crassulaceae	Pathar kuchi	h	M
Caesalpinia pulcherrima (L.) Sw.	Caesalpiniaceae	Radha chura	t	F, N, O
Callistemon citrinus (Curtis) Skeel.	Myrtaceae	Bottle brush	s	N, O
Callistemon linearis DC.	Myrtaceae	Bottle brush	s	N, O
Carica papaya L.	Caricaceae	Pepye	h	Fd, N
Carissa grandiflora A. DC.	Apocynaceae	Karamcha	s	F, Fd, M , N
Cassia alata L.	Caesalpiniaceae	Dad mardon	s	M
Cassia occidentalis L.	Caesalpiniaceae	Kasundi	s	M
Cassia siamea Lam.	Caesalpiniaceae	Minjiri	t	F, N, T
Catharanthus roseus (L.) G. Don	Apocynaceae	Nayan tara	h	O
Ceiba pantandra (L.) Gaertn.	Bombacaceae	Pahari tula	t	T
Cestrum nocturnum L.	Solanaceae	Hasnahena	s	O
Chromolaena odorata (L.) *ex*. King & H.E. Robins.	Asteraceae	Assam gach	h	M, N
Cinnamomum camphora (L.) Prest	Lauraceae	Korpur	t	T
Citrus maxima (Burm. f.) Merr.	Rutaceae	Jambura	s	F, Fd, M
Clitoria ternatea L.	Fabaceae	Aparajita	h	O
Cocos nucifera L.	Arecaceae	Narikel, Coconut	t	Fd, M, N
Codiaeum variegatum Bl.	Euphorbiaceae	Pata bahar	s	O
Colocassia esculenta (L.) Schott.	Araceae	Kochu, Taro	h	Fd, N
Coriandrum sativum L.	Apiaceae	Dhone	h	M
Dalbergia sissoo Roxb.	Fabaceae	Sissoo	t	Fd, N
Delonix regia (Boj. *ex* Hook.) Rafin	Caesalpiniaceae	Krishna chura	t	N
Diospyros discolor Willd.	Ebenaceae	Bilati gab	t	Fd, M, T
Duranta repens L.	Verbenaceae	Kata mehedi	s	M, N
Eucalyptus camaldulensis Dehn.	Myrtaceae	Eucalyptus	t	F, N, T
Eucalyptus citriodora Hook. f.	Myrtaceae	Scented Eucalyptus	t	F, N, T
Gardenia angusta (L.) Merr.	Rubiaceae	Gandha Raj	s	O
Gliricidia sepium (Jacq.) Kunth. *ex* walp	Fabaceae	Gliricidia	t	O, N, T
Glycyrrhiza glabra L.	Fabaceae	Jashti madhu	h	M, N
Gossypium herbaceum L.	Malvaceae	Tula	s	Fd, N
Heliotropium indicum L.	Boraginaceae	Hati sur, Bhurundi	h	M
Hevea brasiliensis Muell.-Arg.	Euphorbiaceae	Rubber	t	N, T
Hibiscus rosa-sinensis L.	Malvaceae	Jaba, China rose	s	O, M, N
Hibiscus sabdariffa L.	Malvaceae	Tok pata, Rosella	h	M, N
Hibiscus schizopetalus (Mast.) Hook. f.	Malvaceae	Jobagach	s	O, M, N
Ipomoea carnea Jacq.	Convolvulaceae	Dholkolmi	h	F, N
Ixora chinensis Roxb.	Rubiaceae	Rongon	s	O
Jatropha gossypifolia L.	Euphorbiaceae	Lal Bherendha	s	M
Lagerstroemia speciosa (L.) Pers.	Lythraceae	Jarul	t	F, N, T
Lantana camara L.	Verbenaceae	Naghful	s	M, N

Lawsonia inermis L.	Lythraceae	Mehedi	s	M, N
Leucaena leucocephala (Lamk.) de Wit	Mimosaceae	Ipil-ipil	t	F, N, T
Litchi chinensis (Gaertn.) Sonn.	Sapindaceae	Litchu	t	Fd, F, N, T,O
Madhuca indica Gmel.	Sapotaceae	Mahua	t	N, T, O
Malachra capitata L.	Malvaceae	Bon Vendhi	s	M
Malvastrum coromondelianum L.	Malvaceae	Bon tara	h	Fd
Malvaviscus sylvestris (L.)	Malvaceae	Morich ful	s	O,N
Melaleuca leucodendron (L.) L.	Myrtaceae	Melaleuca	t	N, T
Melia azedarach L.	Meliaceae	Gora neem, Bokhain	t	Fd, M, T
Mikania cordata (Burm.f.) Robinson	Asteraceae	Germani lata, Tufani lota	c	Fd, M
Mimosa pudica L.	Mimosaceae	Lajja bati	h	M
Mimosops elengi L.	Sapotaceae	Bakul	t	T, O
Mussaenda erythrophylla Vahl	Rubiaceae	Musanda	s	O
Nymphaea capensis Thunb.	Nymphaeaceae	Shapla	h	O
Opuntia dillenii (ker-Gawler) Haw.	Cactaceae	Phoni-monosha	h	O
Opuntia monacantha Haw.	Cactaceae	Phoni-monosha	h	O
Paraserianthes falcataria (L.) Nielsen	Mimosaceae	Moluccana koroi	t	N,T
Peltophorum pterocarpum (DC) Backer ex. Heyne	Caesalpiniaceae	Yellow gold mohur	t	O, T
Pilea microphylla Liebm.	Urticaceae	Maricca lata	c	Nk
Pinus caribaea Morelet var. *hondurensis* Barr & Golf.	Pinaceae	Pine	t	T
Pinus oocarpa Schiede	Pinaceae	Pine	t	T
Plumeria acuminata Ait.	Apocynaceae	Kathali chapa	s	O
Plumeria obtusa Ait.	Apocynaceae	Shorna chapa	s	O
Polyalthia longifolia Thw.	Annonaceae	Debdaru	t	N, T
Psidium guajava L.	Myrtaceae	Peyara	t	F, Fd, M, N
Punica granatum L.	Punicaceae	Dalim	s	F, Fd, M, N
Ravenala madagascariensis Gmel.	Musaceae	Pantha padav	s	O
Ricinus communis L.	Euphorbiaceae	Veranda	h	M, N
Ruellia tuberosa L.	Acanthaceae	Chatpotey	h	N
Samanea saman (Jacq.) Merrill.	Mimosaceae	Ful koroi, Rain tree	t	F, N, T
Santalum album L.	Santalaceae	Sheto chandan	t	M, T
Sesbania grandiflora Pers	Fabaceae	Bokphul	s	O, Fd
Spondias cytherea Sonn.	Anacardiaceae	Bilati amra	t	Fd, M, N, T
Swietenia macrophylla King	Meliaceae	Bara mehogoni	t	T
Swietenia mahagoni (L.) Jacq.	Meliaceae	True Mahagoni	t	T
Syzygium jambos (L.) Alston	Myrtaceae	Jam	t	Fd, F, M, N, T
Syzygium samarengense (Bl.) Merr. & perry	Myrtaceae	Jamrul	t	Fd, M, N
Tamarindus indica L.	Caesalpiniaceae	Tentul	t	Fd, F, M, T
Tectona grandis L. f.	Verbanaceae	Segun, Teak	t	T
Terminalia catappa L.	Combretaceae	Kat badam	t	Fd, M, N
Thuja orientalis L.	Cupressaceae	Thuja	s	O
Thunbergia erecta Roxb.	Acanthaceae	Nilkantha	s	O
Xylia xylocarpa (Roxb.) Taub.	Mimosaceae	Lohakath, Pyankado	t	T

Table 2: Exotic plant species with their habit form (*c = climber, h = herb, s = shrub and t = tree) and uses recorded from Sitakunda Botanical Garden and Eco-park, Chittagong, Bangladesh. [**F= Fuelwood, Fd = Food and Fodder, M = Medicinal, N= Miscellaneous non-timber uses (Other than fuel, fodder and medicinal), O = Ornamental, T = Timber, Nk = Not known].

propagation. The other common trees of the study area were *Hevea brasiliensis* (Rubber), *Melia azedarach* (Ghora neem), *Samanea saman* (Raintree), *Syzygium jambos* (Golap-jam) etc.

A total of 33 exotic shrub species belonging to 27 genera and 18 families were recorded from Sitakunda Eco-park. Maximum shrub species were represented by Malvaceae family (5 species) followed by Apocynaceae (3 species) and Caesalpiniaceae (3 species). The exotic shrub species that commonly occurred in Sitakunda eco-park were *Annona squamosa,Cassia alata*, *Gardenia angusta*, *Hibiscus rosa-sinensis*, *Lawsonia inermis*, *Ravenala madagascariensis*, *Thuja orientalis* etc. *Lantana camara* and *Duranta repens* were the two exotic shrubby species that commonly occurred in the natural ecosystems of Sitakunda Eco-park. *Lantana camara* was observed to grow aggressively in the natural forests along with plantations in the study area.

The study recorded 21 exotic herb species belonging to 20 genera and 17 families in Sitakunda Botanical Garden and Eco-park. Among the 17 families, Araceae, Cactaceae, Fabaceae and Malvaceae were represented by 2 herb species each and the remaining 12 families had only one species each. *Opuntia dillenii* and *Opuntia monacantha* belonging to Cactaceae family were recorded as planted cactus that grown at cactus house in the eco-park. *Mimosa pudica* (Lajjabati), *Chromolaena odorata* (Assamgach) and *Heliotropium indicum* (Hatisur) are the herbs that were growing aggressively in the eco-park area. *Ipomoea carnea* (Dholkolmi) is found to grow along the streams and water bodies with other natural vegetation in the study area. The study area revealed 3 exotic climber species belonging to 3 families. Among the climbers, *Mikania cordata* was found to grow aggressively on the shrubs and trees in the park area. Among all the exotic plant

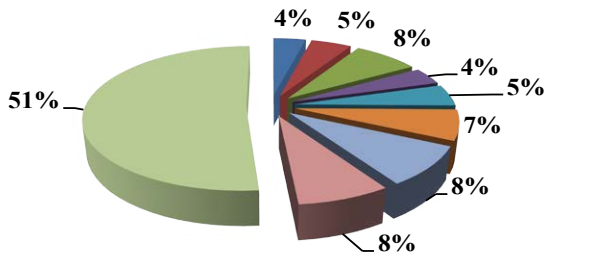

Figure 1: Abundance of exotic plant species belonging to eight dominant families.

species, *Araucaria columnaris, Pinus caribaea, Pinus oocarpa* and *Thuja orientalis* were the four gymnosperms recorded from the plantations of the botanical garden.

Comparison between the native and exotic tree species recorded from the eco-park

The comparative study was done with the plant population data obtained from the sample plots. A total of 74 various tree species belonging to 28 families were recorded from 36 sample plots (10 m × 10 m), where 52 tree species were native and 22 exotic. Maximum number of species were recorded from the valley (42 native and 17 exotic species) followed by mid hill (38 native and 12 exotic species), and hill top (30 native and 15 exotic species). Highest number of species (30 native and 20 exotic species) was recorded in the southern aspects of the hills followed by eastern (22 native and 19 exotic species), western (24 native and 16 exotic species) and northern (28 native and 11 exotic species) aspects. In the study area, maximum number of exotic trees (366.6/ha) were calculated in the valley and lowest number of trees (283.3/ha) were recorded in the top hill. A total number of exotic tree species (288.8/ha) in the southern aspects is found higher than those of other aspects (Table 3).

Among the native species, the relative density was found highest for *Holarrhena antidysenterica* (7.21) followed by *Oroxylum indicum* (6.68) and *Stereospermum colais* (5.98). Maximum relative frequency was calculated for *Stereospermum colais* (7.53) followed by *Oroxylum indicum* (6.33), *Holarrhena antidysenterica* (6.02) and *Ficus hispida* (4.22). Maximum relative dominance was calculated for *Barringtonia acutangula (3.25) followed by Syzygium cumini (3.00) and Mesua ferrae* (3.00).

Among the exotic species, maximum relative density was calculated for *Xylia xylocarpa* (4.75) followed by *Psidium guajava* (4.39) and *Lagerstroemia speciosa* (2.28). The relative frequency was highest for *Xylia xylocarpa* (3.61) followed by *Lagerstroemia speciosa* (2.71) and *Litchi chinensis* (2.71). Maximum relative dominance was calculated for *Polyalthia longifolia* (4.50) followed by *Leucaena leucocephala* (2.63) (Table 4).

The highest Importance Value Index (IVI) was calculated for native species, e.g. *Holarrhena antidysenterica* (14.77) followed by *Stereospermum colais* (14.53) and *Oroxylum indicum* (14.37). On the other hand, among the exotics 2 species showed maximum IVI were *Xylia xylocarpa* (10.05) and *Psidium guajava* (9.15) in the Sitakunda Botanical Garden and Eco-park.

Plant use

Timber, food or fodder, medicine, ornamental, fuelwood were the major use categories considered for categorizing the recorded exotic plants. Plants used for pulp and paper, shade, green manure and latex were grouped under miscellaneous category. A total of 38 exotic plant species having medicinal value were recorded from the Botanical Garden, where 12 species (31%) were trees, 16 (42%) were shrubs, 9 (24%) were herbs and only 1 was climber (Figure 2).

The study also revealed 39 timber yielding exotic trees in Sitakunda Botanical Garden and Eco-park. In addition, 29 exotic plant species (13 tree, 9 shrub, 6 herb and 1 climber species) were found to yield food or fodder (Table 5). Miscellaneous category constituted the major category among all kinds of uses. A total of 58 exotic plant species under miscellaneous category were recorded, where trees were represented by maximum 32 species. Exotic plant species used for ornamental purpose were 29, where trees, shrubs and herbs were represented by 5, 18 and 6 species respectively. A total of 22 exotic species used as fuel wood were recorded from the study area (trees 17, shrubs 4 and herbs 1).

Harmful exotic plants in Sitakunda botanical garden and eco-park

Exotic species have been reported problem for high conservation value areas due to their detrimental effects that can potentially threaten the persistence of native flora and fauna [18,19]. The harmful impacts of alien invasive species are immense and usually irreversible [7]. Some of the exotic plants have luxuriant growth and suppressed the growth of other native species. Some of them are so well established that they are now the dominant species in the park area and became noxious weeds of natural forests, plantations and waste lands e.g. *Chromaelina odorata, Duranta repens, Heliotropium indicum, Ipomoea carnea, Lantana camara, Mimosa pudica* etc.

Impacts of exotic plant species on local community around the eco-park area

Exotic plant species have substantial influence on local

Category		No. of tree species			No. of individual trees			Stem/ha		
		Native	Exotic	Total	Native	Exotic	Total	Native	Exotic	Total
Slope position	Top hill	30	15	45	58	34	92	483.3	283.3	766.6
	Mid hill	38	12	50	63	35	98	525	291.6	816.6
	Valley	42	17	59	78	44	122	650	366.6	1016.6
Aspect	North	28	11	39	45	23	68	500	255.5	755.5
	South	30	20	50	67	26	93	744.4	288.8	1033.3
	East	22	19	41	53	25	78	588.8	277.7	866.6
	West	24	16	40	49	24	73	544.4	266.6	811

Table 3: Number of trees (native and exotic), families and stem per hectare in different slopes and aspects in the eco-park.

Scientific name	Family	Status	RD (%)	RF (%)	RDo (%)	IVI
Acacia auriculiformis	Mimosaceae	E*	0.53	0.30	2.25	3.08
Acacia mangium	Mimosaceae	E	0.35	0.30	1.50	2.15
Achras zapota	Sapotaceae	E	1.23	1.51	1.05	3.79
Adina cordifolia	Rubiaceae	N	0.18	0.30	0.75	1.23
Aegle marmelos	Rutaceae	N	0.88	0.90	1.25	3.03
Albizia richardiana	Mimosaceae	E	1.58	2.11	0.97	4.66
Anacardium occidentale	Anacardiaceae	E	0.53	0.30	2.25	3.08
Anisoptera scaphula	Dipterocarpaceae	N	0.18	0.30	0.75	1.23
Anthocephalus chinensis	Rubiaceae	N	0.53	0.30	2.25	3.08
Aquilaria agallocha	Thymelaeaceae	N	0.53	0.60	1.13	2.26
Araucaria columnaris	Araucariaceae	E	1.05	1.20	1.13	3.38
Artocarpus chama	Moraceae	N	0.35	0.30	1.50	2.15
Artocarpus lakoocha	Moraceae	N	0.53	0.90	0.75	2.18
Azadirachta indica	Meliaceae	N	1.23	1.81	0.88	3.92
Barringtonia acutangula	Lecythidaceae	N	2.28	0.90	3.25	6.43
Bauhinia malabarica	Caesalpiniaceae	N	0.18	0.30	0.75	1.23
Bischofia javanica	Euphorbiaceae	N	0.53	0.30	2.25	3.08
Bombax ceiba	Bombacaceae	E	1.05	1.20	1.13	3.38
Calophyllum inophyllum	Clusiaceae	N	0.35	0.60	0.75	1.70
Cassia fistula	Caesalpiniaceae	N	0.35	0.60	0.75	1.70
Cassia nodosa	Caesalpiniaceae	N	1.58	1.51	1.35	4.44
Castanopsis indica	Fagaceae	N	0.53	0.60	1.13	2.26
Ceiba pantandra	Bombacaceae	E	0.18	0.30	0.75	1.23
Chukrasia tabularis	Meliaceae	N	0.18	0.30	0.75	1.23
Dalbergia sissoo Roxb.	Fabaceae	E	0.70	1.20	0.75	2.65
Dehaassia kuruzii	Lauraceae	N	2.11	2.11	1.29	5.51
Delonix regia	Caesalpiniaceae	E	0.18	0.30	0.75	1.23
Dillenia indica	Dilleniaceae	N	0.53	0.60	1.13	2.28
Dillenia pentagyna	Dilleniaceae	N	2.28	1.81	1.63	5.72
Elaeocarpus seratus	Elaeocarpaceae	N	0.18	0.30	0.75	1.23
Eucalyptus camaldulensis	Myrtaceae	E	1.41	0.90	2.00	4.31
Ficus bengalensis	Moraceae	N	0.35	0.60	0.75	1.70
Ficus glomerata	Moraceae	N	0.35	0.60	0.75	1.70
Ficus racemosa	Moraceae	N	3.34	4.22	1.02	8.58
Ficus religiosa	Moraceae	N	0.35	0.60	0.75	1.70
Holarrhena antidysenterica	Apocynaceae	N	7.21	6.02	1.54	**14.77**
Hopea odorata	Dipterocarpaceae	N	0.35	0.60	0.75	1.7
Hydnocarpus kurzii	Flacourtiaceae	N	1.05	1.51	0.90	3.46
Lagerstroemia speciosa	Lytraceae	E	2.28	2.71	1.08	6.07
Lannea coromandelica	Anacardiaceae	N	2.46	2.11	1.50	6.07
Leucaena leucocephala	Mimosaceae	E	1.23	0.60	2.63	4.46
Litchi chinensis	Sapindaceae	E	1.93	2.71	0.92	5.56
Lophopetalum fimbriatum	Euphorbiaceae	N	0.70	0.90	1.00	2.60
Macaranga denticulata	Euphorbiaceae	N	2.82	3.19	2.24	8.25
Madhuca indica	Sapotaceae	E	0.70	0.90	1.00	2.60
Melia azedarach	Meliaceae	E	0.35	0.30	1.50	2.15
Mesua ferrae	Clusiaceae	N	0.70	0.30	3.00	4.00
Michelia champaca	Magnoliaceae	N	3.16	1.81	2.25	7.22
Mimosops elengi	Sapotaceae	E	0.18	0.30	0.75	1.23
Oroxylum indicum	Bignoniaceae	N	6.68	6.33	1.36	**14.37**
Peltophorum pterocarpum	Caesalpiniaceae	E	1.23	1.51	1.05	3.79
Phyllanthus emblica	Euphorbiaceae	N	2.28	2.41	1.22	5.91
Podocarpus neriifolia	Podocarpaceae	N	0.53	0.60	1.13	2.26
Polyalthia longifolia	Annonaceae	E	1.05	0.30	4.50	5.85
Protium serratum	Buraseraceae	N	0.35	0.60	0.75	1.70
Psidium guajava	Myrtaceae	E	4.39	2.41	2.35	**9.15**
Pterospermum acerifolium	Sterculiaceae	N	0.18	0.30	0.75	1.23
Pterygota alata	Sterculiaceae	N	0.53	0.90	0.75	2.18
Sapindus mukorssi	Sapindaceae	N	0.88	1.51	0.75	3.14
Saraca indica	Mimosaceae	N	1.18	0.30	0.75	1.23

Shorea robusta	Dipterocarpaceae	N	1.76	1.20	1.88	4.84
Sterculia villosa	Sterculiaceae	N	1.23	0.90	1.75	3.88
Stereospermum colais	Bignoniaceae	N	5.98	7.53	1.02	**14.53**
Syzygium cumini	Myrtaceae	N	0.70	0.30	3.00	4.00
Syzygium firmum	Myrtaceae	N	2.99	3.92	0.98	7.89
Syzygium fruticosum	Myrtaceae	N	1.23	1.51	1.05	3.79
Terminalia arjuna	Combretaceae	N	2.28	1.20	2.44	5.92
Terminalia bellirica	Combretaceae	N	1.05	1.51	0.90	3.46
Terminalia catappa	Combretaceae	E	0.35	0.30	1.50	2.15
Toona ciliate	Meliaceae	N	0.71	1.20	0.75	2.65
Trewia nudiflora	Euphorbiaceae	N	1.05	1.20	1.13	6.03
Vitex glabrata	Verbanaceae	N	2.11	2.41	1.13	5.65
Vitex peduncularis	Verbanaceae	N	0.35	0.60	0.75	1.70
Xylia xylocarpa	Mimosaceae	E	4.75	3.61	1.69	**10.05**

Table 4: List of tree species recorded from the 36 sample plots of the Eco-park with their Family, Status (native or exotic), Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo) and Importance Value Index (IVI). [E* = Exotic species, N = Native species].

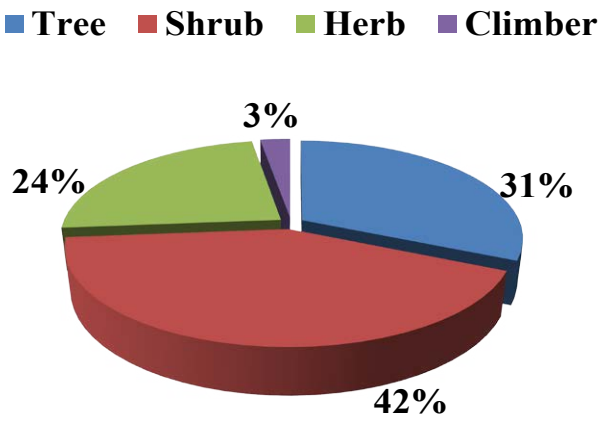

Figure 2: Habit forms of recorded exotic medicinal plant species (%).

Use category	No. of exotic plant species of Sitakunda Botanical Garden and Eco-park				
	Trees	Shrubs	Herbs	Climbers	Total species (No.)
Timber	39				**39**
Food or Fodder	13	9	6	1	**29**
Medicine	12	16	9	1	**38**
Miscellaneous	32	16	9	1	**58**
Ornamental	5	18	6		**29**
Fuel wood	17	4	1		**22**

Table 5: Traditional uses of recorded exotic plant species of various habit forms in the park area.

communities form the view point of improving livelihood and fulfilling fuel-wood needs. Three Focused Group Discussion (FGD) made in the three surrounding villages involving participants from the local communities revealed that more than 75% of the fuel requirements of 90% participants were met by the fuel-wood and litter extracted from the Sitakunda Botanical Garden and Eco-park. People mainly collect branches and litters of *Acacia auriculiformis*, *Acacia mangium*, *Xylia xylocarpa*, *Lagerstroemia speciosa*, *Holarrhena antidysenterica* etc. plants for meeting their fuel demand. Local people also use *Acacia auriculiformis* as one of the important house building implements. The FGDs revealed that *Stereospermum colais, Holarrhena antidysenterica, Toona ciliata, Syzygium* spp. etc. native plants were widely used for both fuel and house building in the past. But, presently people become more dependent on the exotic plants because of their faster growth, usability and availability. In this circumstance, they used to cut and extract forest resources illegally from the Sitakunda Botanical Garden and Eco-park. Exotic plants also provide medicines, fodder, fruits and aesthetic beauty to the local community. Exotic timber trees, in particular, keep important role in the economy of the rural people. Now-a-days surrounding communities of eco-park are planting exotic tree species in their households and harvesting the same when get matured. Various exotic shurbs and herbs such as *Chromaelina odorata, Lantana camara, Mimosa pudica* etc are used as medicinal plants in their day to day life. Flowers of different exotic trees such as *Bauhinia malabarica, Mimosops elengi, Hibiscus rosa-sinensis* etc. are used for religious purposes by the local Hindu communities.

Discussion

The present study revealed a total of 103 exotic plant species from the Sitakunda Botanical Garden and Eco-park which was higher than that's of Hossain and Hossain [7]. Hossain and Hossain [7] recorded 96 exotic plants containing 39 herb species, 35 tree species, 13 shrub

species, and 9 climber species from Chunati Wildlife Sanctuary, Bangladesh. Hossain and Pasha [15] reported 299 exotic plant species (139 herbs, 66 shrubs and 94 trees) from Bangladesh. The present study indicates existence of 26% (103 species) of all exotic plant species of Bangladesh in Sitakunda Botanical Garden and Eco-park, Chittagong.

The study also indicated that some of the common exotic tree species are *Acacia auriculiformis, Acacia mangium*, *Albizia saman*, *Eucalyptus camaldulensis*, *Gliricidia sepium*, *Hevea brasiliensis*, *Leucaena leucocephala*, *Melaleuca leucodendron*, *Paraserianthes falcataria*, *Pinus caribaea*, *Pinus oocarpa*, *Swietenia macrophylla*, *Tectona grandis* and *Xylia xylocarpa.* The species are also common in plantation forests of Bangladesh [5]. Hossain [5] reported 15 exotic tree species which are frequently used in large scale plantation programs of Bangladesh. The present study also revealed 4 exotic gymnosperms which were comparable to 3 exotic gymnosperms in Chunati Wildlife Sanctuary of Bangladesh [7].

The study revealed that massive plantation activities with exotic species like *Xylia xylocarpa* caused its dominance with other native species. Bangladesh Forest Department conducted the plantation activities with exotic species in order to cover the barren areas rapidly and conserve gene pool of wider number of plant species. Though a considerable number of exotic species were introduced in the eco-park area, some native and rare species appeared as dominant species in the eco-park.

The comparative occurrences of the native and exotic plants in different hill slopes and aspects showed that number of exotic species increase or decrease with the native species in different hill slopes of the eco-park. The southern hill aspects showed higher percentage of exotic species than that of other aspects.

Importance Value Index of tree species showed that some native species are still dominant in the study area, whereas some exotics are co-dominant. But, there exists an ecological threat to the native species that many of them may be suppressed by the exotics in the long run. In the present study, maximum Importance Value Index was found for native trees species. Whereas, Hossain and Hossain [7] reported the maximum Importance Value Index (IVI) for exotic tree species namely *Acacia auriculiformis* than other native trees recorded from Chunati Wildlife Sanctuary of Bangladesh.

Surrounding communities are dependent at a greater extant on the both exotic and native plants of Sitakunda Botanical Garden and Eco-park for different forest resources including fuel, medicine, housing materials along with other minor forest produces. People also generate income by selling illegally extracted forest produces (fuel-wood, poles, house building implements, broom grass, bamboo etc.) in the local markets. Apparently, it reduces the recruitment of the seedlings of important exotic and indigenous plantation tree species in the Eco-park. Though, the exotics meet demands of forest produces at a considerable amount, but they are replacing the native plant community gradually which is detrimental to biodiversity and natural ecosystem conservation.

Sitakunda, the first eco-park in Bangladesh, was one of the areas of the country that seems to be rich in biodiversity. Semi-evergreen forests of the eco-park area comprised of many evergreen and deciduous species. As a Botanical Garden, it is playing a vital role in *ex-situ* conservation of biodiversity. A considerable number of woody and non-woody plant species have been planted in this garden [8,12]. A number of exotic plant species along with some rare and native species have also been planted in the garden. But, now a days this park is in great threat due to over exploitation, illicit felling and fuel wood collection by the local people. Intentional fire hazards during dry season were also a great threat to the forest resources. The number of exotic tree species in the park was found comparatively higher than the shrubs and herbs probably because of frequent intentional fire occurrences in previous years.

Conclusion

A number of economically important exotics were introduced in Bangladesh over a long period [6] and these exotic species are getting preferences over the indigenous ones in the plantation programs of the country [20]. After establishment of the Botanical Garden and Eco-park, a considerable number of exotic plant species were introduced in the park area for preserving their gene-pool. It is wise to plant all sorts of plants from gene conservation of wider species point of view but considering conservation of natural ecosystems and native biodiversity population of exotic plants should be controlled. The present findings (103 exotic plant species belonging to 90 genera and 43 families) is a preliminary list of exotic plant species of the park area. For conserving the gene-pool of both native and exotic plant species and securing optimal productivity of all plants on a sustainable basis, it is right time to protect, conserve and manage the garden properly. Further study could also be carried out to assess the ecological impacts of existing exotic plants on native plant species of Sitakunda Botanical Garden and Eco-park.

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