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 Caesalpinioideae (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 colurus (14.53) were the two native tree species that showed maximum Importance Value Index (IVI). Besides, two exotics that showed maximum IVI were Xylica 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 lakh hectares 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, Chittagong, Bangladesh; Tel: 031-716552; E-mail: Shourav.foresstry@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].

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

| 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         |

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 Caesalpiniiaceae (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 Caesalpiniiaceae (5 species). Acacia auriciliformis (Akashmoni), Acacia mangium (Mangium), Eucalyptus camaldulensis (Eucalypt), Melaleuca leuconedron (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
| Scientific name | Family | Local name | Habit | Uses |
|-----------------|--------|------------|-------|------|
| Acacia auriculiformis A. Cunn. ex. Benth | Mimosaceae | Akashmoni | t* | F, N, T** |
| Acacia catechu (L. f.) Wild | Mimosaceae | Khar | t | F, N, T |
| Acacia mangium Wild | Mimosaceae | Mangium | t | F, N, T |
| Acrhis 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 |
| Alistonia macrophylla G. Don | Apocynaceae | Sri Lankan Chatlan | t | F, N, T |
| Amorphophallus campanulatus (Roxb.) Bl. ex Dane. | Araceae | Ol kochu | h | Fd, T |
| Anacardium occidentale L. | Anacardiaceae | Kaju Badam | t | Fd, N, T |
| Annona reticulata | Annonaceae | Atah | s | Fd, M, N |
| Annona squamosa L. | Annonaceae | Santha | s | Fd, M, N |
| Antigonon leptopus Hook. & Am. | Polygonaceae | Ananta lata | c | N |
| Arajria columnaris (Frost. F.) Hook. | Anacardiaceae | X-mass tree | t | N |
| Artabotrys odoratissimus R. Br. | Anonaceae | 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. | Caesalpinaceae | Kanchan | s | N, O |
| Bombax ceiba | Bombacaceae | Simul tula | t | N, T |
| Borassus flabellifer L. | Arecaceae | Tal | t | Fd, M, N, T |
| Bougainvillia spectabilis Willd. | Nyctaginaceae | Bagan blash | s | N, O |
| Bryophyllum pinnatum (Lam.) Oken. | Crassulaceae | Patthar kuch | h | M |
| Caesalpinia pulcherrima (L.) Sw. | Caesalpinaceae | 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. | Caesalpinaceae | Dad mardon | s | M |
| Cassia occidentalis L. | Caesalpinaceae | Kasundi | s | M |
| Cassia siamea Lam. | Caesalpinaceae | Minjiri | t | F, N, T |
| Catharanthus roseus (L.) G. Don | Apocynaceae | Nayan tara | h | O |
| Ceiba pentandra (L.) Gaerth. | Bombacaceae | Pahari tula | t | T |
| Cestrum nocturnum L. | Solanaceae | Hasnahaena | s | O |
| Chromolaena odorata (L.) ex King & H.E. Robins. | Asteraceae | Assam gach | h | M, N |
| Cinnamomum camphora (L.) Pres | Lauraceae | Korpur | t | T |
| Citrus maxima (Burm. f.) Merr. | Rutaceae | Jambura | s | F, Fd, M |
| Clitoria ternatea | Fabaceae | Aparajita | h | O |
| Cocos nucifera L. | Arecaceae | Narikel, Coconut | t | Fd, M, N |
| Codiaeum variegatum Bl. | Euphorbiaceae | Pata bhar | s | O |
| Colocasia 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 | Caesalpinaceae | Krishna chura | t | N |
| Diospyros discolor Wild. | Ebenaceae | Bilati gab | t | Fd, M, T |
| Duranta repens L. | Verbenaceae | Kala 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 |
| Glycyrhiza glabra L. | Apiaceae | Jashth madhu | h | M, N |
| Gossypium herbaceum L. | Malvaceae | Tula | s | Fd, N |
| Heliotropium indicum L. | Boraginaceae | Hati sur, Bharundi | h | M |
| Hevea brasiliensis Muel-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 |
| Ipomea batatas Jacq. | Convolvulaceae | Dhokolmol | h | F, N |
| Ipomoea cairica | Convolvulaceae | Dholkolm | h | F, N |
| Jatropha gossypifolia L. | Euphorbiaceae | Lal Bherendha | s | O |
| Lagerstroemia speciosa (L) Pers. | Lythraceae | Jarul | t | F, N, T |
| Lantana camara L. | Verbenaceae | Naghful | s | M, N |
Annona squamosa, Cassia alata, Apocynaceae (3 species) and Caesalpiniaceae (3 species). The exotic families were recorded from Sitakunda Eco-park. Maximum shrub (Golap-jam) etc. Syzygium jambos (Raintree), (Ghora neem), Samanea saman (Rubber), brasiliensis propagation. The other common trees of the study area were Pinus caribaea and Lawsonia inermis. 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 had only one species each.

### 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**]

| Exotic Species | Family | Uses | Habit Form |
|----------------|--------|------|------------|
| Annona squamosa | Annonaceae | - | c |
| Cassia alata | Fabaceae | - | h |
| *Opuntia dillenii* (ker-Gawler) Haw. | Cactaceae | F, N, T | s |
| *Opuntia monacantha* How. | Cactaceae | O | s |
| *Parasenianthes falcata* (L.) Nielsen | Mimosaceae | T | h |
| *Ful koroi* | Mimosaceae | Fd, F, M, N | s |
| *Shapla* | Nymphaeaceae | T | h |
| *Peyara* | Myrtaceae | Fd, F, M, N | t |
| *Ful koroi* | Mimosaceae | O, T | s |
| *Peyara* | Myrtaceae | Fd, M, N | s |
| *Ful koroi* | Mimosaceae | O, T | s |
| *Peyara* | Myrtaceae | Fd, M, N | t |
| *Ful koroi* | Mimosaceae | O, T | s |
| *Peyara* | Myrtaceae | Fd, M, N | t |

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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 along 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 grow at cactus house in the eco-park. *Mimosa pudica* (Lajabati), *Chromolaena odorata* (Assamgach) and *Heliotropium indicum* (Dholkolmi) 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 shrub 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
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 x 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 eco-park area.

Using the diversity indices, the diversity of native species (4.92) and exotic species (4.67) were found highest in 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 eco-park area.

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

| Category     | Slope position | Aspect | No. of tree species | No. of individual trees | Stem/ha |
|--------------|----------------|--------|----------------------|-------------------------|---------|
|               |                |        | Native | Exotic | Total | Native | Exotic | Total | Native | Exotic | Total |
| 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 |
| North         | 28             | 11     | 39     | 45       | 23     | 68     | 500    | 255.5  | 755.5  |
| South         | 30             | 20     | 50     | 67       | 26     | 93     | 744.8  | 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    |

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| 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      | 0.68   | 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 |
| *Antocephalus 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   | 1.61   | 0.88    | 3.92 |
| *Barringtonia acutangula*| Lecythidaceae        | N      | 2.28   | 0.90   | 3.25    | 6.43 |
| *Bauhinia malabarica*   | Caesalpiniaeae        | 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*        | Caesalpiniaeae        | N      | 0.35   | 0.60   | 0.75    | 1.70 |
| *Cassia nodosa*         | Caesalpiniaeae        | N      | 1.58   | 1.51   | 1.35    | 4.44 |
| *Castanopsis indica*    | Fagaceae              | E      | 0.53   | 0.60   | 1.13    | 2.26 |
| *Ceiba pentandra*       | Bombacaceae           | E      | 0.18   | 0.30   | 0.75    | 1.23 |
| *Chukrasia tabularis*   | Meliaceae             | N      | 0.18   | 0.30   | 0.75    | 1.23 |
| *Dalbergia sissoo*      | Fabaceae              | E      | 0.70   | 1.20   | 0.75    | 2.65 |
| *Dehaassia kurzii*      | Lauraceae             | N      | 2.11   | 2.11   | 1.29    | 5.51 |
| *Delonix regia*         | Caesalpiniaeae        | E      | 0.18   | 0.31   | 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 serulus*   | 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 |
| *Hollariahna antidysenterica*| Apocynacea         | N      | 7.21   | 6.02   | 1.54    | 14.77 |
| *Hopea odorata*         | Dipterocarpaceae      | N      | 0.35   | 0.60   | 0.75    | 1.70 |
| *Hydnocarpus kurzii*    | Flacouriaceae         | 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 flaviflorum*| Euphorbiaceae       | N      | 0.70   | 0.90   | 1.00    | 2.60 |
| *Macaranga decipulata*  | 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 |
| *Oxylum indicum*        | Bignoniaceae          | N      | 6.68   | 6.33   | 1.36    | 14.37 |
| *Peltophorus pteroxypus*| Caesalpiniaeae        | E      | 1.23   | 1.51   | 1.05    | 3.79 |
| *Phylichclus emblica*   | Euphorbiaceae         | N      | 2.28   | 2.41   | 1.22    | 5.91 |
| *Podocarpus nutifolia*  | Podocarpaceae         | N      | 0.53   | 0.60   | 1.13    | 2.26 |
| *Polyalthia longifolia* | Annoraceae            | E      | 1.05   | 0.30   | 4.50    | 5.85 |
| *Protium serratum*      | Burseraceae           | N      | 0.35   | 0.60   | 0.75    | 1.70 |
| *Psidium guajava*       | Myrtaceae             | E      | 4.39   | 2.41   | 2.35    | 9.15 |
| *Pterospermum acutifolium*| Sterculiaceae      | N      | 0.18   | 0.30   | 0.75    | 1.23 |
| *Ptitygoa alata*        | Sterculiaceae         | N      | 0.53   | 0.90   | 0.75    | 2.18 |
| *Sapindus mukorsai*     | Sapindaceae           | N      | 0.88   | 1.51   | 0.75    | 3.14 |
| *Saraca indica*         | Mimosaceae            | N      | 1.18   | 0.30   | 0.75    | 1.23 |
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*, *Mimosops elengi*, *Hibiscus rosa-sinensis* etc. are used for religious purposes by the local Hindu communities.

**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].

| Species                  | Family         | Status | RD | RF  | RDo | IVI |
|--------------------------|----------------|--------|----|-----|-----|-----|
| 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     | Bignoniacae    | 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 jambosum        | 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 ciliata            | 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 5:** Traditional uses of recorded exotic plant species of various habit forms in the park area.

| Use category | No. of exotic plant species of Sitakunda Botanical Garden and Eco-park |
|--------------|---------------------------------------------------------------------|
|              | Trees | Shrubs | Herbs | Climbers | Total species (No.) |
| Timber       | 39    | 39     | 6     | 1        | 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     | 1        | 29 |
| Fuel wood    | 17    | 4      | 1     |           | 22 |

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

**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, Gliciridia sepium, Hevea brasiliensis, Leucaena leucocephala, Melaleuca leucodendron, Paraserianthes falcataria, Pinus caribaea, Pinus oucharpa, Swietenia macropylla, 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 extent 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.

References

1. Barua SP, Khan MMH, Reza AHMA (2001) The Status of Alien Invasive species in Bangladesh and their Impact on the Ecosystems. In: Alien Invasive Species – Report on Workshop on Alien Invasive Species, P Balakrishna (Ed.). IUCN Regional Biodiversity Programme of Asia, Colombo, Sri Lanka. 1-7.
2. Hossain MK (2001) Overview of the forest biodiversity in Bangladesh. In: Assessment, Conservation and Sustainable use of Forest Biodiversity, CBD Technical Series no. 3, Secretariat of the Conservation on Biological Diversity. Montreal, 33-35.
3. Nishat A, Huq SMI, Barua SP, Reza AHMA, Khan ASM (2002) Bio-ecological zones of Bangladesh, The World Conservation Union (IUCN), Dhaka, Bangladesh.
4. Hassan MM (1995) Biodiversity Conservation and Management in Bangladesh: A state of the art, Review, ICIMOD, Kathmandu, Nepal Hill.
5. Hossain MK (2008) The Contribution and Critic of Exotic Species in the Plantation Forestry of Bangladesh. In: Exotics in Indian Forestry, Agrotech Publishing Academy, Udaipur, India, 324-335.
6. Islam AKMN (1991) Two Centuries of plant studies in Bangladesh and adjacent regions. In: Asiatic Society of Bangladesh, Dhaka, Bangladesh, 299.
7. Hossain MK, Hossain MA (2014) Biodiversity of Chunati Wildlife Sanctuary: Flora, Arananny Foundation, Dhaka, Bangladesh, 175.
8. Alam MK (2001) Development Plan for Sitakunda Botanical Garden and Eco-park, Office of the Director and Conservator of Forests, Chittagong Circle, Forest Department, Chittagong, Bangladesh.
9. MoEF (Ministry of Environment and Forests) (2000) Project Document on Establishment of Sitakunda Botanical Garden and Eco-park, Chittagong, Government of the Peoples’ Republic of Bangladesh.
10. Rahman MA, Uddin SB (1997) Angiospermic flora of Sitakunda in Chittagong, Bangladesh. Journal of Plant Taxonomy 4: 17-36.
11. Misbahuzzaman K, Alam MJ (2006) Ecological Restoration of Rainforest through Aided Natural Regeneration in the Denuded Hills of Sitakunda, Chittagong, Bangladesh. International Journal of Agriculture & Biology 48: 118-124.
12. Uddin MS, Hossain MK, Huda SMS (2005) Distribution pattern of Medicinal Plant species in Sitakunda Botanical Garden and Eco-park of Chittagong, Bangladesh. Hamdard Medicus 48: 118-124.
13. Prain D (1903) Bengal Plants, Botanical Survey in India, Calcutta, India, 1-1103.
14. Das DK, Alam MK (2001) Trees of Bangladesh. Bangladesh Forest Research Institute, Chittagong, Bangladesh, 10-301.

15. Hossain MK, Pasha MK (2004) An account of the exotic flora of Bangladesh. Journal of Forestry and Environment 2: 99-115.

16. Ahmed ZU, Begum ZNT, Hassan MA, Khondker M, Kabir SMH, et al. (2008) Encyclopedia of Flora and Fauna of Bangladesh, Asiatic Society of Bangladesh, Dhaka.

17. Shukla RS, Chandel PS (1980) Plant Ecology, S. Chand and Company Ltd, New Delhi, India, 197.

18. Biswas SR, Choudhury JK, Nishat A, Rahman MM (2007) Do invasive plants threaten the Sundarbans mangrove forest of Bangladesh? Forest Ecology and Management 245: 1-9.

19. Stinson KA, Campbell SA, Powell JR, Wolfe BE, Callaway RM, et al. (2006) Invasive plant suppresses the growth of native tree seedlings by disrupting below ground mutualisms. PloS Biology 4: 727-731.

20. FMP (Forestry Master Plan) (1993) Forestry Master Plan: Main Plan – 3/2012, Ministry of Environment and Forest, Govt. of Bangladesh, 162.