

Floral diversity in the central part of Chattogram city, Bangladesh

Floral
diversity

Trapa Biswas, Shourav Dutta, Md. Akhter Hossain,
Md. Rayhanur Rahman, Saddam Hossen and
Mohammed Kamal Hossain
(*Author affiliations can be found at the end of the article*)

185

Received 31 January 2021
Revised 6 March 2021
Accepted 6 March 2021

Abstract

Purpose – This study/paper aims to evaluate the floral richness of the central part of Chattogram city, Bangladesh. Chattogram is recognized as the largest port city and the commercial capital of Bangladesh, which confronts faster urbanization and swift infrastructure development. Green spaces in and around Chattogram city are shrinking sharply, which resulted in rapid loss of floral and faunal resources in this area. The present study was carried out from February 2018 to January 2019 to enumerate the vascular plant species of the Sulakbahar ward located in the central part of Chattogram City, Bangladesh.

Design/methodology/approach – The study area was categorized into 10 habitats to assess the variation of floral composition. The extensive whole area survey method was applied to record the flora from all sorts of plant habitats of the research area.

Findings – The study enumerated 418 vascular plant species under 315 genera and 120 families including natural, planted and cultivated from the study area. The habit form of the recorded plant composition indicated that herbs (35%) constitute the major plant category followed by trees (34%), shrubs (17%), climbers (12%), ferns (1%) and orchids (1%). The study also indicated that exotic species (50.3%) became dominant than native species (49.7%) in Chattogram city because of their scenic beauty, easy propagation and ornamental value to the city planners and inhabitants.

Originality/value – It appeared that floral resources of the Chattogram city area are in great threat due to aggressive and unplanned infrastructure development for housing, offices and institutions by replacing the

© Trapa Biswas, Shourav Dutta, Md. Akhter Hossain, Md. Rayhanur Rahman, Saddam Hossen and Mohammed Kamal Hossain. Published in *Ecofeminism and Climate Change*. Published by Emerald Publishing Limited. This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at <http://creativecommons.org/licences/by/4.0/legalcode>

The authors cordially acknowledge the Chittagong City Corporation, Bangladesh for providing funding and necessary support to conduct this study. Moreover, the authors are really thankful to the Biodiversity Research Group of Bangladesh for its support in the fieldwork. The authors also acknowledge the Institute of Forestry and Environmental Sciences, University of Chittagong; and BFRI, Bangladesh for extending their supports during the taxonomical activities.

Conflict of interest: Authors have declared that no competing interests exist.

Contribution of the authors: This research was conducted in collaboration among all authors with simultaneous efforts. Author TB collected, compiled and analyzed the data and wrote the main protocol. Author SD (corresponding author) managed literature searches, performed data compilation, statistical analysis and prepared the first and final draft of the manuscript to finalize it. Authors MRR and SH collected and compiled the species data and managed literature searches. Authors MAH and MKH identified the species, designed the research, delivered the guidelines, did overall supervision, reviewed and evaluated the final draft of the manuscript.



green spaces. The study recommended that urgent protection measures should be taken to conserve and protect the existing floral resources for the well-being of the urban people.

Keywords Bangladesh, Conservation, Urban green space, Roof-top garden, Urban plant diversity

Paper type Research paper

1. Introduction

The largest delta of the world – Bangladesh, lying in the north-eastern part of South Asia, dwelt at the cross borders of the Indo-Himalayan and Indo-Chinese sub-region, is the harbor of a wide variety of flora and fauna (Dutta *et al.*, 2014; Foster-Turley *et al.*, 2016). About 5,000 species of angiosperms alone are residing in Bangladesh of which around 2,260 species are enumerated from the Chattogram zone of Bangladesh (Anon, 1992; CRPARP, 2015; Foster-Turley *et al.*, 2016). The landscapes of the Chattogram region of Bangladesh, categorized by hills, hillocks, flatlands, wetlands, canals, rivers and the Bay of Bengal, etc. reflect a rich ecological heritage of giant animals, insects, birds, fishes, angiosperms, gymnosperms, climbers, vines and plants with medicinal and aesthetic values (Dutta and Hossain, 2020; Hossain, 2001).

Chattogram, the southeastern part of Bangladesh, was established in 1666 with a total area of about 5,282.92 km² including the Chittagong Hill Tracts (CHTs) and Cox's Bazar (BBS, 2011). The natural heritage and floristic composition of Chattogram city attracted plant explorers and taxonomists from prehistoric times and provided a basis to conduct floristic research in that evergreen city (Anon, 2003; Uddin *et al.*, 2015). Urban forests of the city area play a vital role to protect tree species diversity, as well as to confirm the environmental sustainability and also the entity of green landscapes of the Chattogram Metropolitan Area (Anon, 2003). However, it is very unfortunate that Chattogram city losses its beauty and biological heritage faster due to the rapid unplanned urbanization and anthropogenic activities, i.e., illegal cutting of trees and hills, unplanned slum and housing, excessive infrastructure development, etc. Uddin and co-researchers reported that hill cutting, urbanization and industrialization tremendously affect biodiversity distribution of several hills and urban forests of Chattogram city (Uddin *et al.*, 2015). Hence, we need to effectively preserve and efficiently manage this rich biological diversity and ascertain the green spaces in Chattogram city of Bangladesh for the betterment of future city dwellers (Hossain, 2004; Uddin *et al.*, 2015).

Both urban biological diversity and ecological sustainability are tremendously threatened due to the rapid progress of urbanization (Elmqvist *et al.*, 2013; Uddin *et al.*, 2015). Urbanization creates a devastating scope for land degradation, separation of urban green cover and tremendous loss of urban biological diversity (Elmqvist *et al.*, 2013). Green parks, domestic gardens, homestead plantations, botanical gardens and recreational parks and remnant forest patches are the major elements of urban green spaces (Jaganmohana *et al.*, 2018). Due to rapid urbanization, a few plant species are seen in the urban landscapes of Chattogram city. Meanwhile, the overall floral composition and vegetation coverage of the Chattogram urban area has been changed due to several anthropogenic disturbances and ongoing encroachments (Uddin *et al.*, 2015). It is necessary to assess the floral composition of Chattogram city for sustainable urban planning and management.

Uddin and co-researchers recorded 65 tree species under 28 families from the hilly areas of Chattogram city and surrounding areas (Uddin *et al.*, 2015). Dutta and co-researchers recorded 332 vascular plants under 266 genera and 93 families from a nearby botanical garden and eco-park of Chattogram city, Bangladesh (Dutta *et al.*, 2014). However, there is

no recent study that covers the complete floral diversity of the Chattogram city area or any part of it.

In that regard, it is important to record the present flora of the Chattogram city to help in developing chronological baseline information and monitoring changes. In this study, an attempt has been made to evaluate the floral richness of the central part of Chattogram city, Bangladesh. Another objective of the present study was to assess the distribution of vascular plant species in different habitats of the Chattogram city, Bangladesh.

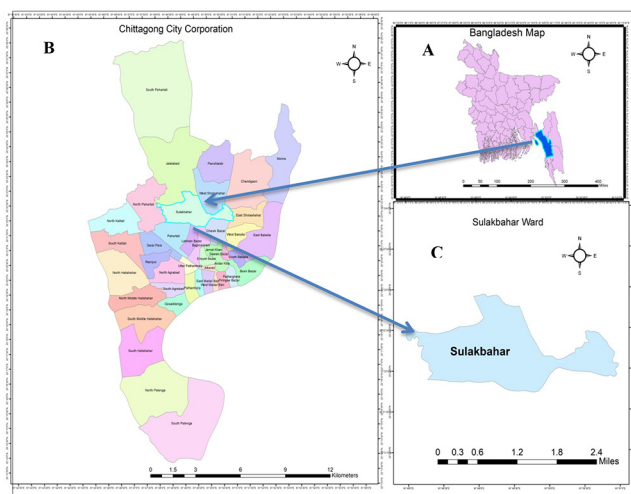
2. Materials and methods

2.1 Study site

Chittagong (Officially Chattogram), established in 1666, is a large port city on the south-eastern coast of Bangladesh. Chattogram resides latitudinally between 21°54'N and 22°59'N; and longitudinally within 91°17'E and 92°13'E (BBS, 2011). The Chattogram city comprises an area of about 171 km² with around 6.0 million of population (BBS, 2011). The study was conducted in the Sulakbahar ward [1] comprising almost the central part of the Chattogram City Corporation (CCC). The area has a variety of land uses e.g., industrial, residential, educational, vacant lands, hills, markets, etc. (Figure 1).

2.2 Physiographic condition of the study area

Chattogram lies at the straddles of the coastal foothills of CHTs in south-eastern Bangladesh and enjoys a moist tropical climate with 25.7°C mean annual temperature, 2,794 mm of annual precipitation and 78% mean annual humidity (MAH) (Climate data, 2018). The properties of urban soils differ greatly from agricultural lands to the particular area of hills. The soil types in urban areas of Chattogram city are sandy loam, loamy sand and silt loam with 53%–83% sand (Alamgir *et al.*, 2015).



Notes: (a) administrative units of Bangladesh with the location of Chattogram district; (b) administrative parts (wards) of Chattogram city corporation; (c) central part of Chattogram city (study site: Sulakbahar ward)

Figure 1.
The study area

2.3 Collection and compilation of data

Prior to the fieldwork, a reconnaissance survey was conducted in the study area to gain a general idea about physiographic and overall conditions of the study site with particular attention to species composition, nature of species occurrence and habitat of the vascular plant species. The identified potential plant habitats were fallow land (plain), fallow land (hill), graveyard, institution, homestead, nursery, roadside and island, water-body, industrial area, roof-top, etc. Most of these habitats were spread across the study areas and interwoven.

As the research approach was to find total diversity in the whole study area, that is why we have included all available units for the floral survey. All types of observed plant species (i.e., herbs, shrubs, timber, non-timber, exotics, native, orchids, ferns, cactus, etc.) occurring in the above-mentioned habitats were identified and recorded in the field by their species names. Plant samples of unknown species were collected to prepare herbarium.

Data about the purpose of planting or site-specific use of the plants was also collected. The assessment of floral composition in the rooftop garden was determined by the interviewees' perception and field observation. The indoor plants including the plants occurring on the balcony of the households were recorded together with roof-top plants.

2.4 Identification of the collected specimens and data analysis

Herbarium was prepared with the fertile materials of plant samples and mounted on a sheet of paper of standard size 29.21 cm × 41.91 cm (11.5" × 16.5"). A tag with the information such as local name, scientific name, area of collection, collection time, habit, habitat, family, collector's name was attached with each sheet. The unknown samples were identified with the help of taxonomists of the Forest Botany Division of Bangladesh Forest Research Institute (BFRl). A consultation with published journals and reference books, e.g., Bengal Plants (Prain, 1903); Encyclopedia of Flora and Fauna of Bangladesh (Ahmed *et al.*, 2008, 2009); Trees of Bangladesh (Das and Alam, 2001), etc. was also conducted to identify the plant specimens.

Identified plants were compiled together, and categorized based on their habitat and habit forms. Then, the relative proportion of the number of species in different habit forms, habitats, nature of occurrence (i.e., exotic or native) and taxonomic families, etc. were estimated. Moreover, the plants were categorized based on the purpose of the plantation.

All the collected data and information (qualitative and quantitative) were gathered in an MS Excel sheet and sorted carefully. Then, we rearranged all the data in a systematic way to acquire the intended results from this research. Finally, we analyzed the compiled data using spreadsheets (MS Excel, version: 2010) and demonstrated the findings in the form of figures and tables.

3. Results

3.1 Floral composition

The study enumerated a total of 418 vascular plant species under 315 genera and 120 families from the central urban part (Ward-8: Shulakbahar) of Chattogram city, Bangladesh. Among the 418 vascular plants, herbs formed the major habit (145 species) and occupied around 35% of all the recorded plant species followed by trees (34%), shrubs (17%), climbers (12%), orchids (1%) and ferns (1%). We categorized all the recorded plants based on their habit forms, then classified and demonstrated under genus and family (Table 1).

The most common tree species of the study area were *Acacia auriculiformis* (Akashmoni), *Acacia mangium* (Mangium), *Albizia lebbek* (Kala koroi), *Albizia procera*

(Sada koro), *Azadirachta indica* (Neem), *Delonix regia* (Krishnachura), *Gmelina arborea* (Gamar), *Syzygium cumini* (Kalo jam), etc. *A. auriculiformis* (Akashmoni), *A. mangium* (Mangium) and *Eucalyptus camaldulensis* (Eucalyptus), etc. were three common plantation tree species recorded from the study area.

The study clearly enumerated 73 shrub species belonging to 65 genera and 58 families. Some commonly occurred shrubs in the study area were *Allamanda cathartica* (Alakananda), *Cissus quadrangularis* (Harjora), *Duranta erecta* (Kata mehendi), *Hibiscus rosa-sinensis* (Joba), *Ixora acuminata* (Rongon), etc. The study recorded 145 herb species (127 genera and 120 families). *Acmella uliginosa* (Nakful), *Aloe vera* (Grithokumari), *Bryophyllum pinnatum* (Pathorkuchi), *Canna indica* (Kolaboti), *Impatiens balsamina* (Dopati), *Zinnia elegans* (Zinnia), etc. herbs were commonly found in the study area.

There were some ornamental climbers, i.e. *Bougainvillea glabra*, *Clitoria ternatea*, *Cuscuta reflexa*, *Epipremnum aureum*, *Heliconia rostrata*, *Hiptage benghalensis*, *Ipomoea quamoclit*, *Jasminum sp.*, etc. that were recorded from the homesteads and roof-top gardens. Three common ferns recorded were *Adiantum incisum* (Biddapata), *Christella arida* (Bishdhekia) and *Lindsaea ensifolia* (Bon-dhekia). Three orchid species belonging to Orchidaceae family, i.e. *Aerides odorata* (Shakful), *Cymbidium aloifolium* (Churi) and *Phalaenopsis deliciosa* (Phalaenopsis) were observed in the study area.

The present study recorded three gymnosperms, among which *Cycas pectinata* (Cycas) was the only native gymnosperm whereas, *Araucaria cunninghamii* (Araucaria) and *Pinus oocarpa* (Pine) recorded as exotic tree species in the study area. *Thuja orientalis* (Thuja) was the exotic ornamental shrub commonly found in the nursery and also in the institute premises.

The present study revealed a distinctive variation among the abundance of various vascular plant species belonging to different families. In this study, we found that 15 dominant families contained about 48% of the total plant species and the remaining 52% plant species under the rest of 105 families (Figure 2). Maximum number of species (24) was contained by Asteraceae family followed by Poaceae (21 species), Euphorbiaceae (18 species), Fabaceae (16 species), Araceae (14 species), Apocynaceae (13 species) and Arecaceae (13 species).

3.2 Occurrence of plant species in 10 habitats

The study recorded the highest number of plant species from the home gardens and nurseries in comparison with other habitats. Maximum tree species were found in the nursery (98 species), followed by home garden (94 species), institution (89 species), graveyard (63 species), plain fallow land (62 species) and hilly areas (44 species) (Table 2). The study recorded 143 plant species occurring in the plain fallow lands followed by 80 plant species in the hilly fallow areas. Our study enumerated a total of 183 plant species belongs to 162 genera and 77 families from the premises/campus of the institutions. However, the minimum number of tree species (19) was recorded from the industrial area

Sl. No.	Plant category	Species	Genus	Family	Species %
01.	Tree	140	95	118	34
02.	Shrub	73	65	58	17
03.	Herb	145	127	120	35
04.	Climber	52	47	42	12
05.	Fern	3	3	3	1
06.	Orchid	3	3	1	1

Table 1.
Categorization of the vascular plants recorded from the Central urban part (Ward-8) of chattogram city

and near water bodies (36). In the case of herbs, maximum (57) was recorded from the rooftop gardens followed by the home garden (47) and plain fallow areas (41). On the other hand, the maximum number of shrub species (52) was enumerated from the rooftop gardens followed by institutional areas (43) and home gardens (39).

Polyalthia longifolia, *Samanea saman* and *Terminalia catappa*, etc. are the common tree species found in the roadside plantations and institutional areas. *Colocasia esculenta* (Kochu), *Lemna perpusilla* (Khudipana), *Nelumbo nucifera* (Lotus), *Nymphaea candida* (Lily), *Nymphaea nouchali* (Shapla), *Eichhornia crassipes* (Kochuripana), etc. were the common aquatic plant species in the water bodies. *Azadirachta indica* (Neem), *Ficus hispida* (Dumur), *Streblus asper* (Sheora), etc. were the common tree species found near the water bodies and beside canals.

3.3 Indigenous and exotic trees with their distribution

In the present research, a comparative study between native and exotic plant species revealed that exotic species (50.3% of all 418 species) became more common than native (49.7%) species due to their aesthetic value and low space occupancies in the indoor, rooftop and premises. This study recorded 210 exotic plant species under 112 families and 208 native species under 99 families. This is maybe because of wider adaptability in the

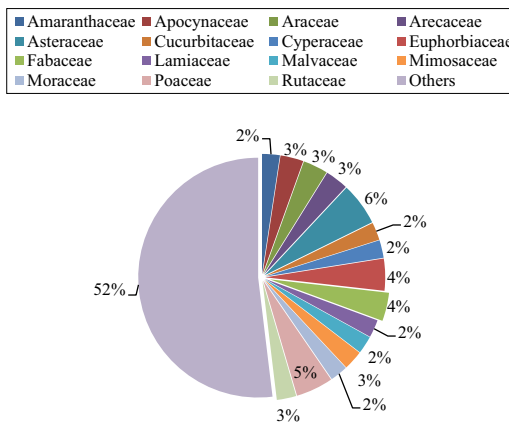


Figure 2. Abundance of vascular plant species in 15 dominant families

Table 2. Number of vascular plant species recorded from different habitats

Sl. No.	Habitat	Tree	Shrub	Herb	Climber	Fern
01.	Fallow land (plain)	62	17	41	15	4
02.	Fallow land (hill)	44	8	15	6	3
03.	Graveyard	63	15	5	3	0
04.	Home garden	94	39	47	21	0
05.	Institution	89	43	39	12	0
06.	Nursery	98	36	33	21	0
07.	Roadside or island	40	4	12	0	0
08.	Rooftop	38	52	57	30	0
09.	Water-body	36	3	11	6	0
10.	Industrial area	19	0	1	0	0

nurseries, low mortality, scenic values, easy propagation and suitability of the exotic species for ornamental plantations.

Maximum number of species was recorded from the rooftop gardens (25 natives and 88 exotic species) followed by nursery (32 natives and 75 exotic species), home garden (44 native and 59 exotics) and graveyard (53 native and 48 exotic species) (Table 3).

Highest percentage (75%) of exotic species was recorded from the roof-top gardens and lowest (31%) was recorded from the plain fallow lands. Maximum percentage (68%) of native species was found from the plain fallow lands, whereas the lowest (21%) was revealed from the roof-top gardens (Figure 3).

The comparative study on the occurrence of indigenous and exotic species in different habitat revealed that the proportion of exotic species was increasing in comparison to indigenous species in several habitats because of their faster growth and low mortality rate. In some plantations, exotic species were found where native species were very low in number. These results indicated that people are willing to establish the plantation of exotic species rather than indigenous plant species.

3.4 Roof-top gardens of ornamental, native and introduced plants

Hobby and environmental considerations are the main purposes of rooftop gardening in most cases as revealed by the present survey. Beautification, recreation, etc. are also some common reasons for rooftop gardening in the study area. Some people opined it as a good means of passing ones' leisure time. During the field survey, it was observed that rooftop

Sl. No.	Habitat	Native	Exotic	Total
01.	Plain fallow land	49	45	94
02.	Hilly land	65	34	99
03.	Graveyard	53	48	101
04.	Home garden	44	59	103
05.	Institutional area	43	57	100
06.	Roadside or island	35	55	90
07.	Water body	59	41	100
08.	Industrial area	32	48	80
09.	Roof top garden	25	88	113
10.	Nursery	32	75	107

Table 3.
Number of plant species (native or exotic) at different habitat in the study area

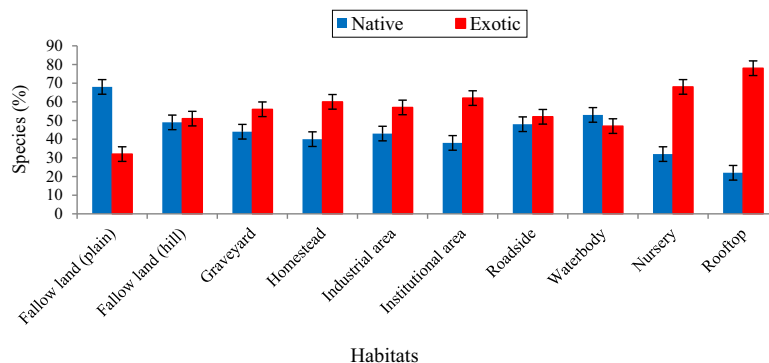


Figure 3.
Distribution (percentage) of native and exotic plant species in different habitats

gardens were managed by the local communities for fruit and vegetable productions. In some cases, people mentioned that they managed roof-top gardens for biodiversity and environmental conservation. This study also revealed that women are engaged more (60%) in roof-top gardening than that of the males (40%).

Seedlings and graftings were popular as the planting materials used by the gardeners for raising roof-top gardens. Around 70% of the interviewees opined that they collect the planting materials from the nearby nursery, hawker, exhibition and relatives' gardens among which nursery is the very feasible source.

3.5 Threats posed by the exotic plants

Exotic plants are deliberated as a great threat to the native biodiversity and ecosystems due to their deleterious influences on the existence and survival of indigenous plants and wildlife (Biswas *et al.*, 2007; Dutta *et al.*, 2015). The present study clearly stated that several exotic plants have aggressive growth, and also have negative impacts on the growth and development of native tree species. A number of well-established exotic tree species, i.e., *Acacia auriculiformis*, *Albizia richardiana*, *Araucaria cunninghamii*, *Dalbergia sisso*, *Eucalyptus camaldulensis*, etc. and some noxious exotic weeds, e.g., *Chromolaena odorata*, *Duranta erecta*, *Lantana camara*, *Mimosa pudica*, etc. were recorded from the plantation sites of different habitat.

3.6 Non-woody medicinal plant resources

In the present study, 24 non-woody medicinal plant species (belonging to 21 genera and 14 families) were enumerated from the study area including cultivated and planted. Of the 24 non-woody medicinal plant species, 13 species were herbs, 9 species were shrubs and only 2 species were climbers (Figure 4).

Aloe vera, *Centella asiatica*, *Coriandrum sativum*, *Scoparia dulcis*, etc. were the common herbs recorded from the home gardens. *Abelmoschus esculentus*, *Capsicum annum*, *Citrus aurantifolia*, etc. were the common plantation shrub species recorded from the graveyards, home gardens and hilly areas. *Calotropis gigantea* and *Urena lobata* were the only two medicinal shrub species naturally grown in the study area.

The abundance of non-woody medicinal plant species in different families showed a comprehensive variation. Among them, 71% of species were represented by seven dominant families, whereas 29% of species by others. The most dominant seven families were Apiaceae (three), Araceae (three), Solanaceae (three), Apocynaceae (two), Malvaceae (two), Rutaceae (two) and Zingiberaceae (two) (Figure 5).

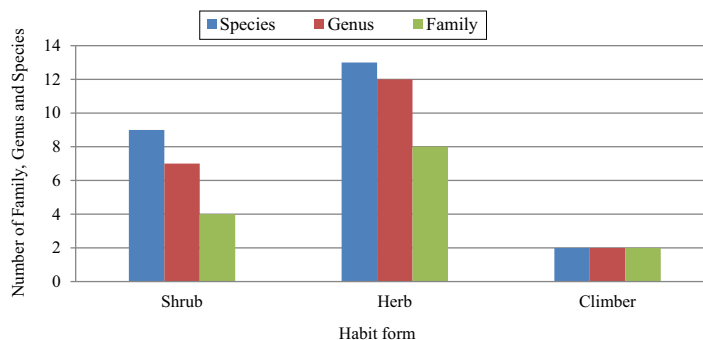


Figure 4. Non-woody medicinal plant composition in the study area

3.7 Bamboo, rattan and cactus species

The survey recorded five bamboo species of which *Bambusa vulgaris* and *Melocanna baccifera* were common in plantations. One rattan (*Calamus guruba*) and one cactus species (*Echinopsis pachanoi*) were found as plantations. In this survey, Chhan (*Imperata cylindrica*) infested areas also revealed that indicates degraded soils with low fertility.

4. Discussion and recommendations

4.1 Discussion

The survey indicated the floral composition of the central part (Ward 8: Shulakbahar) of Chattogram city area of Bangladesh representing the overall structural features of plants occurred in the parks, roadsides, home gardens, institutes, industries, hills, water bodies, plantations and graveyards in Chattogram city. The floral richness (418 plant species) of the central urban part of Chattogram city was comparatively higher than the Dhaka South City of Bangladesh recorded by Jaman and researchers in 2017 (Jaman *et al.*, 2017), where they reported 221 plant species (under 63 families) from the central urban lands of Dhaka city (south) in Bangladesh.

This study recorded about 418 vascular plants from the central urban part of Chattogram city, which was lower than that is of Rahman (2013); where the researcher recorded 425 angiosperms (under 321 genera and 108 families) containing 113 trees, 74 shrubs, 186 herbs and 52 climbers from the Rajshahi district of Bangladesh (Rahman, 2013). A comparison of floral richness among the three major cities of Bangladesh is shown in Figure 6.

The study recorded only 24 medicinal non-woody plant species (9 shrubs, 13 herbs and 2 climbers) from the study area, which was lower than the medicinal plants mentioned by Akber and co-researchers; where the researchers recorded about 67 medicinal plant species from the Khulna city of Bangladesh (Akber *et al.*, 2011).

The survey enumerated only three gymnosperms from the Chattogram city area, which was comparatively lower than the Chunati Wildlife Sanctuary (CWS), Chattogram by Hossain and Hossain (2014) and Sitakunda Botanical Garden and Eco-park (SBGE), Chattogram by Dutta *et al.* (2014). Hossain and Hossain (2014) enumerated only four and Dutta *et al.* (2014) recorded eight gymnosperms from the CWS and SBGE, respectively.

The result of the study indicated the availability of some common plantation tree species (*Acacia auriculiformis*, *Gmelina arborea*, *Swietenia macrophylla*, *Tectona grandis*, etc.) in the study area, which supports the findings of similar research (Dutta *et al.*, 2015; Uddin *et al.*, 2015) conducted in Chattogram, Bangladesh. The study also revealed the occurrence of Chhan (*Imperata cylindrica*) at different habitats in the study area, which implies the

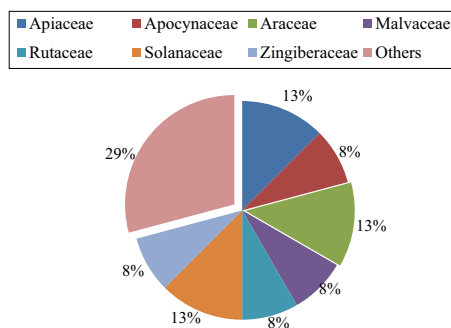


Figure 5.
Abundance of non-woody medicinal plant species in seven dominant families

presence of low fertile soils with less soil moisture in the Chattogram city area according to the report of [Dutta and Hossain \(2016\)](#).

Based on fieldwork, a strengths, weaknesses, opportunities and threats (SWOT) analysis was performed to assess the opportunities and available strengths to conserve the native plant species of Chattogram city ([Table 4](#)). SWOT analysis was conducted through an extensive field survey and using the key findings of the study prescribed by [Dutta and Hossain \(2020\)](#). The main strength is that vegetation coverage in the graveyards and some other habitats (institutions, nurseries, etc.) is quite dense due to sacredness, proper management and less accessibility. Such areas are mostly protected as a source of biodiversity hotspot, storing carbon and minimizing pollution. Sacredness and spiritual values are really helpful to protect the native trees in the Chattogram city area.

The major weakness identified in this study is that the management of plantations and plant resources is not locally conducted in a scientific approach. Local communities could be aware and skilled enough regarding the preservation, protection and conservation of the existing flora through an urban-forestry scientific approach. Promoting green approaches; raising awareness among city dwellers about urban forestry should be developed by government or non-governmental organizations (NGOs) in a convenient way.

This study recorded the existence of several native plant species from the plain and hilly fallow areas. Such opportunities indicated that both plain and hilly fallow sites have the last hope to build green spaces. Support from the authority for monitoring the plant composition is another opportunity to conserve the existing flora. However, roof-top gardening has seemed to a prominent sector for urban greening as it is getting popularity for ornamentation, as well as growing fruits and vegetables.

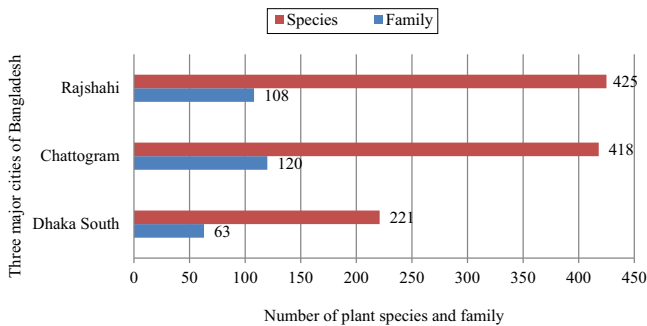


Figure 6.
Floral richness in the three major cities of Bangladesh

Table 4.
SWOT analysis of plant protection and conservation values in the study area

Strengths

1. Vegetation coverage in several habitats
2. Sacredness protects plant diversity
3. Plantation of native and exotic tree species

Opportunities

1. Existence of native plant species
2. Adequate support from the authority
3. Roof-top gardening by local inhabitants
4. Increased assessment and monitoring

Weaknesses

1. Unscientific management
2. Lack of skills about nature conservation
3. Lack of awareness among the communities

Threats

1. Rapid and unplanned urbanization
2. Encroachment in the hills and green spaces
3. Extreme infrastructure development
4. Presence of exotics and habitat fragmentation

The findings of the study clearly showed that unplanned urbanization has caused serious ecological imbalances in Chattogram city. Furthermore, land-cover changes and conversion of natural patches to housing threaten the habitats of plant species day by day. In this regard, the sustainable urban forestry approach should be an effective pathway for improving the current status of plant diversity and the green spaces in the study area.

4.2 Recommendations

The following recommendations were made after reviewing the major findings of this study:

- Urban forestry should be increased in urban communities to conserve the rare native plant species in different habitats.
- Institutional premises (such as school, college, university and hospital) and industrial areas should be brought under plantation programs, and those have vegetation coverage should maintain properly.
- Policymakers should think about several habitats to introduce the afforestation programs by negotiating discussion with the landowners.
- Policy about green coverage should formulate and develop to manage the roof-top gardens in a sustainable way.

The present study also highly recommended that green NGOs could develop partnerships and synergies with different stakeholders to ensure the rich floral diversity in the Chattogram city area of Bangladesh.

5. Conclusion

Chattogram city of Bangladesh is facing extreme unplanned urbanization problems due to the high population, unplanned housing, illegal cutting of trees and hills, encroachments in fallow lands, excessive infrastructure development, etc. Some major challenges for conserving the floral diversity in the Chattogram city are minimizing faster urbanization, eradicating ecological deterioration, restoring natural resources and mitigating climate change. Meanwhile, sustainable management of plant communities in the Chattogram city area is very important for assuring the ecological amelioration, environmental development and socio-economic upliftment of the city inhabitants.

The present study focuses on an inventory of vascular plant composition of the central part (Shulakbahar ward) of Chattogram city, Bangladesh. The findings of 418 vascular plants (under 315 genera and 120 families) at different habit forms in the Chattogram city area need immediate conservation plan. The findings of the study provide only baseline information; further study needs to be carried out to evaluate the ecological and environmental effects of existing flora on urban ecosystems of Chattogram city, Bangladesh.

Note

1. Ward is the lowest administrative unit of City Corporation of Bangladesh.

References

- Ahmed, Z.U., Begum, Z.N.T., Hassan, M.A., Khondker, M., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A. and Rahman, A.K.A. and Haque, E.U. (Eds) (2009), *Encyclopedia of Flora and Fauna of Bangladesh. 5-8 and 12, Angiosperms: Dicotyledons and Monocotyledons*, Asiatic Society of Bangladesh, Dhaka.

- Ahmed, Z.U., Begum, Z.N.T., Hassan, M.A., Khondker, M., Kabir, S.M.H., Ahmad, M., Ahmed, A.T. A. and Rahman, A.K.A. and Haque, E.U. (Eds) (2008), *Encyclopedia of Flora and Fauna of Bangladesh. 6-10 and 12, Angiosperms: Dicotyledons and Monocotyledons*, Asiatic Society of Bangladesh, Dhaka.
- Akber, M., Seraj, S., Islam, F., Ferdousi, D., Ahmed, R., Nasrin, D., Nahar, N., Ahsan, S., Jamal, F. and Rahmatullah, M. (2011), "A survey of medicinal plants used by the traditional medicinal practitioners of Khulna city, Bangladesh", *American-Eurasian Journal of Sustainable Agriculture*, Vol. 5 No. 2, pp. 177-195.
- Alamgir, M., Islam, M., Hossain, N., Kibria, M. and Rahman, M. (2015), "Assessment of heavy metal contamination in urban soils of Chittagong city, Bangladesh", *International Journal of Plant & Soil Science*, Vol. 7 No. 6, pp. 362-372, doi: [10.9734/IJPSS/2015/18424](https://doi.org/10.9734/IJPSS/2015/18424).
- Anon (1992), "Forestry master plan (FMP)", Government of Bangladesh, Ministry of Environment, Forest and Climate Change. UNDP/FAO BGD 88/025, p. 66.
- Anon (2003), "Chittagong city corporation (CCC) takes up healthy city project", *The Weekly Holiday*, Country News, Dhaka, pp. 1-10.
- BBS (2011), "Bangladesh population and housing census, community report: Chittagong", available at: www.bbs.gov.bd (accessed 26 June 2018).
- Biswas, S.R., Choudhury, J.K., Nishat, A. and Rahman, M.M. (2007), "Do invasive plants threaten the Sundarbans mangrove forest of Bangladesh?", *Forest Ecology and Management*, Vol. 245 Nos 1/3, pp. 1-9.
- Climate data (2018), "Chittagong climate: average temperatures, weather by month", *Chittagong weather averages - Climate-Data.org [WWW Document]*, available at: <https://en.climatedata.org/location/4059/> (accessed 22 September 2018).
- CRPARP (2015), "Forestry master plan and national forestry policy (2016-2030)", available at: <http://crparpbf.org/project-activities/forestry-master-plan/> (accessed 26 June 2018).
- Das, D.K. and Alam, M.K. (2001), *Trees of Bangladesh*, Bangladesh Forest Research Institute (BFRI), Chittagong, pp. 9-301.
- Dutta, S. and Hossain, M.K. (2016), "Infestation of *Imperata cylindrica* L. and its impacts on local communities in secondary forests of Sitakunda Botanical Garden and Eco-Park, Chittagong, Bangladesh", *International Journal of Conservation Science*, Vol. 7 No. 1, pp. 167-180.
- Dutta, S. and Hossain, M.K. (2020), "Bringing back the chakaria sundarbans mangrove forest of South-East Bangladesh through sustainable management approach", *Asian Journal of Forestry*, Vol. 4 No. 2, pp. 65-76.
- Dutta, S., Hossain, M.K., Hossain, M.A. and Chowdhury, P. (2014), "Floral diversity of Sitakunda Botanical Garden and Eco-park in Chittagong, Bangladesh", *Indian Journal of Tropical Biodiversity*, Vol. 22 No. 2, pp. 106-118.
- Dutta, S., Hossain, M.K., Hossain, M.A. and Chowdhury, P. (2015), "Exotic plants and their usage by local communities in the Sitakunda Botanical Garden and Eco-Park, Chittagong, Bangladesh", *Forest Research*, Vol. 4, p. 136.
- Elmqvist, T., Fragkias, M., Goodness, J., Güneralp, B., Marcotullio, P.J., McDonald, R.I., Parnell, S., Schewenius, M., Sendstad, M., Seto, K.C. and Wilkinson, C. (2013), "Urbanization, biodiversity and ecosystem services: challenges and opportunities: a global assessment", *Food Security and Ecosystem Support in Urbanizing world-Springer*, Vol. 26, pp. 505-506.
- Foster-Turley, P., Das, R., Hasan, M.K. and Hossain, P.R. (2016), "Bangladesh tropical forests and biodiversity assessment", available at: www.usaid.gov/sites/default/files/documents/1865/Bangladesh-Tropical-Forests-and-Biodiversity-Assessment-2016.pdf (accessed 26 June 2018).
- Hossain, M.K. (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*, pp. 33-35.

-
- Hossain, M.K. (2004), "Final report on national biodiversity specialist (flora)", *Biodiversity Strategy and Action Plan Project*, pp. 1-197.
- Hossain, M.K. and Hossain, M.A. (2014), *Biodiversity of Chumati Wildlife Sanctuary: Flora*, Arannayk Foundation and Bangladesh Forest Department. Dhaka. p. 175.
- Jaganmohana, M., Vailshery, L.S., Mundolic, S. and Nagendrac, H. (2018), "Biodiversity in sacred urban spaces of Bengaluru, India", *Urban Forestry and Urban Greening*, Vol. 32, pp. 64-70.
- Jaman, M.S., Jahan, I., Jamil, M. and Hossain, M.F. (2017), "Structure and composition of plant across different urban land vegetation in Dhaka South city, Bangladesh", *Journal of Agriculture and Ecology Research International*, Vol. 13 No. 4, pp. 1-14.
- Prain, D. (1903), *Bengal Plants, Vol. 1&2. (1st. Repr.1963)*, Botanical Survey in India, Calcutta, pp. 1-1103.
- Rahman, A.H.M.M. (2013), "Angiospermic flora of Rajshahi district, Bangladesh", *American Journal of Life Sciences*, Vol. 1 No. 3, pp. 105-112, doi: [10.11648/j.ajls.2013010315](https://doi.org/10.11648/j.ajls.2013010315).
- Uddin, M.N., Alam, O., Uddin, M.M., Hoque, A.T.M.R. and Misbahuzzaman, K. (2015), "Diversity and distribution of tree species in the hills of Chittagong metropolitan area, Bangladesh", *Journal of Biodiversity and Environmental Sciences*, Vol. 6 No. 4, pp. 89-99.

Author affiliations

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

Shourav Dutta, Department of Forestry and Environmental Science, Rangamati Science and Technology University, Rangamati, Bangladesh

Md. Akhter Hossain, Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong, Bangladesh

Md. Rayhanur Rahman, Faculty of Science and Forestry, University of Eastern Finland, Joensuu, Finland

Saddam Hossen, Department of Forestry and Environmental Science, Rangamati Science and Technology University, Rangamati, Bangladesh, and

Mohammed Kamal Hossain, Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong, Bangladesh

Corresponding author

Shourav Dutta can be contacted at: shourav.forestry@gmail.com and shourav.fes@rmstu.edu.bd

For instructions on how to order reprints of this article, please visit our website:

www.emeraldgrouppublishing.com/licensing/reprints.htm

Or contact us for further details: permissions@emeraldinsight.com