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Invasive alien species of Bangladesh

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Abstract

Bangladesh has a history of species introduction from different geographic regions. The country was a major trade route during the early-modern era and was under British colonial rule until 1947s. Many species of plants and animals are either domesticated or cultivated at different times that were brought into the country by the settlers, seamen, and traders. The deliberate preferences of fast-growing, high-yielding exotics in recent decades also threaten the existence of native species and their genetic resources in the country. Here we provide an overview of the invasive alien species in Bangladesh, likely pathways of their introduction, their impacts on ecosystem and people, and strategies for their effective management and regulation. Many exotic plants and animals both terrestrial and aquatic have found to be invasive in the country with negative impacts on local ecosystems, biodiversity, and livelihoods. Collectively, those species possess serious threats to country's agriculture, forestry, and fisheries sector. Although initially introduced to favor primary productivity or other environmental benefits, many of these are now regarded as obnoxious pest or weed in Bangladesh. A comprehensive list of invasive species both for native and exotics and a framework to characterize them is also absent in the country. We recommend a separate statutory body and appropriate rules and policies for the introduction, monitoring, and management of alien species in the country. Community awareness, advocacy, surveillance, capacity building of relevant government staff and agreement with neighboring countries for transboundary management of invasive alien species is also necessary.

Keywords: Biodiversity loss, Climate change, Ecosystems, Exotic species, Agriculture, Forestry, Fisheries.

Contents

1. Introduction

During the past decades, invasive alien species (IAS) have gained wider recognition by scientists and policymakers for their severe ecological and economic impacts worldwide (Early et al. 2016; Mukul et al. 2006). At the same time, IAS has been identified as one of the greatest threats to native ecosystems, habitat, and species (Guido and Pillar 2017; Mukul et al. 2006). Increasing globalization facilitates the arrival of IAS in new regions, and environmental changes, including global warming, facilitate their establishment worldwide (Early et al. 2016). Human-mediated transport beyond biogeographic barriers has also led to the introduction and establishment of IAS in new regions (Dawson et al. 2017; Turbelin et al. 2017). IAS recognized for their rapid growth, efficient dispersal capabilities, large reproductive output, and tolerance to a broad range of environmental conditions over native or local species (Hellmann et al. 2008; Campbell 2005).

Bangladesh has a long history of species introduction from different countries or geographic regions (Hossain 2009; Barua et al. 2001). More than 300 exotic species are assumed to be either domesticated or cultivated in the country at different times, of which there are no records (Hossain and Pasha 2001; Ali 1991). Several plant species, mainly herbs, and shrubs were introduced in the country during the British colonial period for their aesthetic value (Mukul et al. 2006). Most of the timber species were introduced during the late 1980s to meet the country's rapidly growing demand for timber, fuelwood, and fodder (Ahmed et al. 2008; Mukul et al. 2006). In recent years, some fish species have been introduced primarily to increase productivity to support the nutrients needs of a huge population (Galib and Mohsin 2010; Hossain 2009). Although, invasive alien species is a growing reality in Bangladesh, they are still largely ignored and unnoticed (Akter and Zuberi 2009). This chapter aims to provide an overview of invasive alien species in Bangladesh, their impacts on ecosystems and society, introduction pathways, and strategies for management with a general background of the country's geography, land-use/land cover, ecosystem, and biodiversity.

2. Geography and climate of Bangladesh

Bangladesh is a country of about 143,999 square kilometres (km^2) and is bordered by India in the west, north, and east except for a small portion in the southeast by Myanmar (Figure 1). The entire south is occupied by the Bay of Bengal. Geographically, the country is located between 88° 01'E and 92° 41' East longitude, and between 20° 34' and 26° 33' North latitude (Rashid 1991). The majority of the country's land is formed by river alluvium from the Ganges and the Brahmaputra and their tributaries, which consists mostly of flood plains (80%) with some hilly areas (12%) (Sohel et al. 2015). More than fifty transboundary rivers feed into the country, effectively creating the world's second largest riverine drainage basin, the Ganges-Brahmaputra-Meghna (GBM) basin, and the largest delta of the world (Hofer and Messerli 2006).

Bangladesh enjoys a tropical monsoon climate, which is characterized by high temperatures, heavy rainfall, excessive humidity, and fairly marked seasonal variations (Brammer 2016). There are three distinct seasons in the country: a hot, humid summer from March to June; a cool, rainy monsoon season from June to October; and a cool, dry winter from October to March. Maximum summer temperatures range between 30°C-40°C. April is the warmest month whilst January is the coldest month with an average temperature of about 10°C all over the country. Much of the country receives at least 2000 mm of annual rainfall, while part of the west,

northwest, and north-eastern Bangladesh receive the greatest average precipitation, often over 4000 mm per year (Rashid 1991).

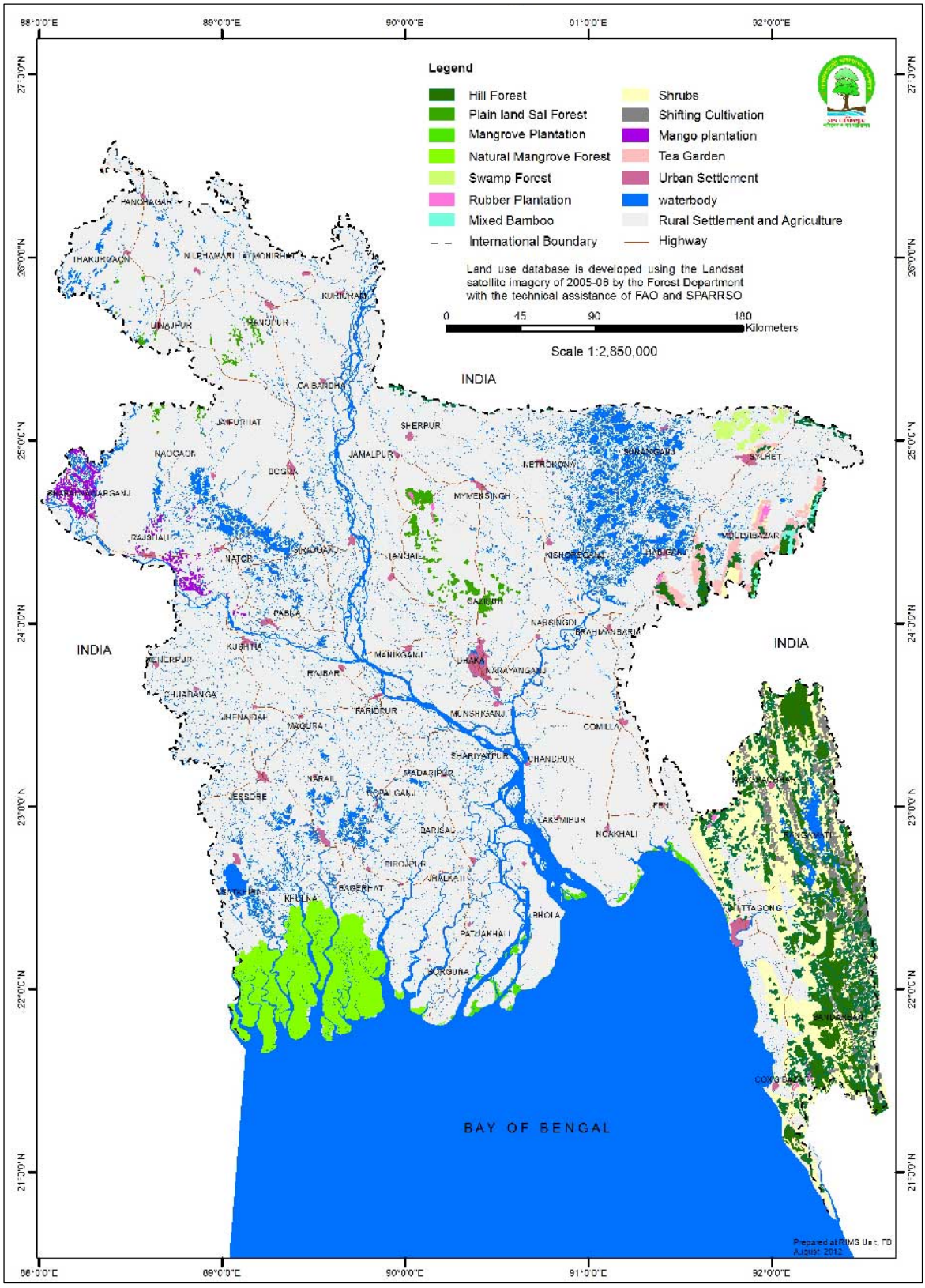

Figure 1. Major land-use/land cover and ecosystem types of Bangladesh. (Source: Bangladesh Forest Department 2016)

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3. Land-use/land cover and ecosystems of Bangladesh

In Bangladesh, agriculture is the major land-use, comprising nearly 65% of the country's total land area, followed by forests (17.5%), urban/built-up areas (8%), and water (Figure 2; Mukul et al. 2014). Forests occupy nearly 2.53 million hectares in Bangladesh and mostly degraded in nature (Mukul et al. 2017). Of these, 1.52 million hectares are under the jurisdiction of the Bangladesh Forest Department (FD) (Mukul et al. 2017; Table 1). The remaining forests areas are unclassed state forests under the control of district administration and homestead forests owned by smallholder landowners (Khan et al. 2007; Mukul 2007).

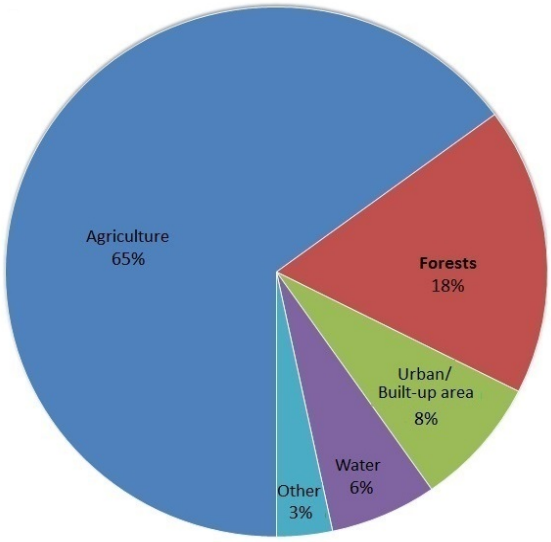

Figure 2. Major land-use/land cover of Bangladesh.

Table 1. Forest ecosystems of Bangladesh.

Forest type	Area (million ha)	Percentage of country's land area (%)
Hill Forests	0.67	4.5
Sal Forests	0.12	0.8
Mangrove Forests	0.60	4.1
Mangrove Plantations	0.13	0.9
Unclassed State Forest	0.73	4.9
Homestead Forests	0.27	1.8
Total	2.53	17.5

Source: Mukul et al. (2017)

The majority of the lands are arable in Bangladesh, therefore, suitable for agriculture. Among the field crops, rice is the main staple crop, occupying 70% of the gross cropped area under agricultural land-use. Agricultural land often subjected to weed and insect attacks influencing productivity and management costs. The country's water body mainly comprised of rivers, ponds, canals, and lakes filled with a variety of aquatic plants, fish and migratory birds. Among the forests, the Sundarbans mangrove forests are in relatively good condition and together with hill forests, they represent the most diverse ecosystem in the country (Mukul et al. 2019, 2014). People are highly dependent on hill forests and Sal forests and FD established several plantations using native and exotic species there (Khan et al. 2007).

4. Biodiversity in Bangladesh

Although a small country, Bangladesh is exceptionally endowed with a rich biodiversity due to its unique geophysical location (Mukul et al. 2018). An estimated 5,700 species of angiosperms alone, including 68 woody legumes, 130 fiber yielding plants, 500 medicinal plants, 29 orchids, 3 gymnosperms and 1,700 pteridophytes has been recorded from the country (Islam 2003). The country also possesses a rich faunal diversity although many are now under different degrees of threats due to changing climate and anthropogenic pressure (Mukul et al. 2019, 2012; Alamgir et al. 2015). Approximately 138 species of mammals, 566 species of birds, 167 species of reptiles, 49 species of amphibians, 708 species of marine and freshwater fish, 2,493 species of insects, 19 species of mites, 164 species of algae (and seaweed) and 4 species of echinoderms have so far been recorded from the country (Table 2) (IUCN 2015).

Table 2. Faunal diversity (vertebrates) of Bangladesh.

Group	Total no. of species	Extinct	Threatened			
			Critically endangered	Endangered	Vulnerable	Total
Amphibians	49	0	2	3	5	10
Reptiles	167	1	17	10	11	39
Birds	566	19	10	12	17	58
Mammals	138	11	17	12	9	49
Total	920	31	46	37	42	156

Source: IUCN (2015)

5. Invasive alien species in Bangladesh

A complete and reliable inventory of invasive alien species is still lacking in Bangladesh. The majority of the exotic species were introduced into the country without any proper documentation (Barua et al. 2001). There are also contradictions in the definition and the use of the term IAS in Bangladesh, and not all the exotics are harmful (Mukul et al. 2006). Table 3 provides a list of common IAS in Bangladesh based on secondary literature. Most of the IAS in the country were brought by settlers, invaders, seamen, and traders. Few of the invasive species, mainly plants, were introduced during the colonial period as an ornamental species for their aesthetic value (Mukul et al. 2006). Perhaps the first widely introduced IAS in Bangladesh is Water Hyacinth (*Eichhornia crassipes*) which was brought from Brazil during the British colonial period (Barua et al. 2001). In recent years, deliberate preferences of fast-growing, high-yielding cultivars over native species caused the introduction of some potentially harmful exotic species in the country (Hossain 2009). The introduction of Acacia and Eucalyptus from Australia during the 1980s created several controversies in the country. All the species belongs to these two genera are proven to be rivals to the endemic flora and found to be environmentally unfriendly (Ameen 1999). The initial list of IAS prepared by Zabala (1990) of angiospermic flora of the country listed nine species, i.e. *Acacia auriculiformis*, *A. mangium*, *Albizia falcataria*, *Dalbergia sisso, Eucalyptus camaldulensis, E. brassiana, Leucaena leucocephala, Swietenia macrophylla, S. mahagony,* although not all of them fulfill the criteria of IAS (Akter and Zuberi 2009).

Other invasive plants are widespread in forests, wastelands, agricultural landscapes, and aquatic ecosystems mostly as noxious weed (see–Uddin et al. 2013; Biswas et al. 2012, 2007; Khan et al. 2011; Akter and Zuberi 2009; Hossain 2009; Mukul et al. 2007; Islam et al. 2003; Barua et al.

2001; Hossain and Pasha 2001). Some of the world's worst IAS like, *Chromolaena odorata, Lantana camara, Mikania micrantha,* are also abundant in Bangladesh with a detrimental impact on local species and natural ecosystems (Ahmed et al. 2007). Figure 3 shows some of the common invasive alien plant species in different ecosystems of the country.

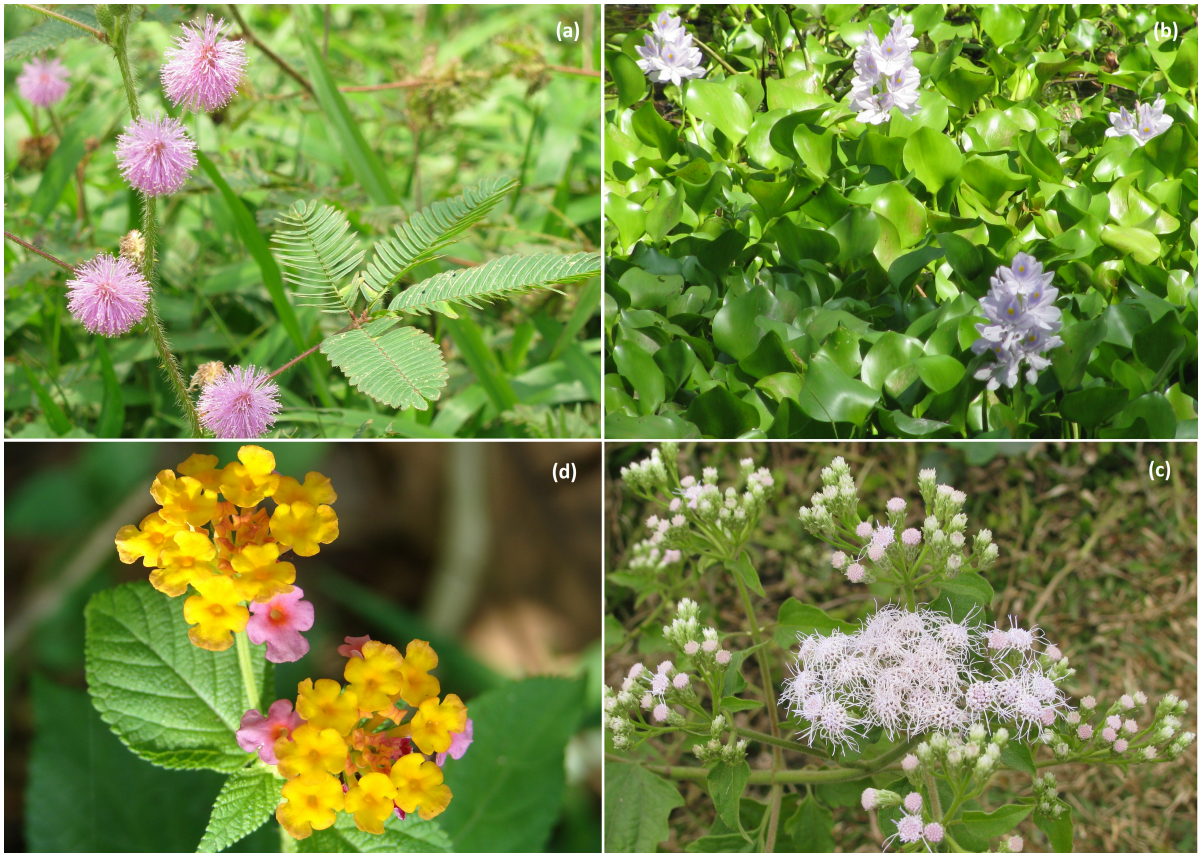

Figure 3. Some common invasive alien plant species in Bangladesh (clockwise) – (a) Touch-me-not (*Mimosa pudica*), (b) Water hyacinth (*Eichhornia crassipes*), (c) Billy goat weed (*Ageratum conyzoides*) and (d) Lantana (*Lantana camara*).
(Photo credit: Sharif A. Mukul)

Among the fauna, most of the reported IAS are fish and mostly carps. The predatory habit of these carp species is well recognized. Although others are not predatory, their fecundity and growth rate are extremely high, and they are able to breed naturally (Barua et al. 2001). Many of these species were brought to the country from Thailand during the 1990s. Currently, the most 'disastrous' invasive alien fish species in the country are - *Clarias gariepinus*, *Pangasius sutchi*, *Pangasius giganticus*, *Tilapia mossambica* and *Oreochromis niloticus* (Rahman 1997). All of these species also recognized as the world's worst invasive alien species (Lowe et al. 2004). A large number of ornamental and game fish have also been introduced in Bangladesh in the past decades (Galib and Mohsin (2011).

Other invasive alien fauna includes a bird species (*Columba livia*), several insects and a species of mollusks (*Achatina fulica*). This list, however, does not epitomize the actual situation of IAS in the country. Many agricultural pests and microorganisms which have been brought to the country during agricultural trade remain unrecorded. In recent years, unregulated wildlife trade and imports, and a growing urban market of wildlife also caused the introduction of some potentially invasive fauna into the country's terrestrial ecosystem many of which remained unidentified.

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Table 3. Invasive alien species reported from different ecosystems of Bangladesh.

Life form	Scientific name	Common name	Origin/ Native range	Habitat type(s)	Major use(s)	Occurrence	Level of invasion	Source(s)
Bird	*Columba livia*	Rock pigeon	Europe	TER	P	++	++	1
Fish	*Aristichthys nobilis*	Bighead carp	China	AQU	F	++	++	8
	Carassius auratus	Goldfish	Europe, Asia	AQU	O	+	+	8
	Clarias gariepinus	African sharptooth catfish	Africa	AQU	F	++	++	1, 8
	Ctenopharyngodon idella	Grass carp	China, Russia	AQU	F	++	++	1, 8
	Cyprinus carpio	Common carp	China, Russia	AQU	F	++	++	1, 8
	Gambusia affinis	Mosquito fish	Armenia, Mexico	AQU	O	++	++	1
	Hypophthalmichthys molitrix	Sliver carp	China, Russia	AQU	F	++	++	1, 8
	Lebistes reticulatus	Guppy	South America	AQU	F	++	++	8
	Mylopharyngodon piceus	Black carp	China	AQU	F	++	++	8
	Oreochromis mossambicus	Common tilapia	Africa	AQU	F	++	++	1, 8
	Oreochromis niloticus	Nilotica	Africa	AQU	F	++	++	1, 8
	Pangasius giganticus	Giant pangas	NA	AQU	F	++	++	8
	Pangasius sutchi	Pangas	Thailand	AQU	F	++	++	8
	Pterygoplichthys multiradiatus	Armored catfish	NA	AQU	O	++	++	1
	Puntius gonionotus	Thai sarpunti	Thailand	AQU	F	++	++	8
	Trichogaster pectoralis	Siamese gourami	Singapore	AQU	F, O	++	++	8
Insect	*Bemisia tabaci*	Silverleaf whitefly	NA	AGR	P	++	++	1
	Diaphorina citri	Asian citrus psyllid	Asia	AGR	P	++	++	1
	Paratrechina longicornis	Crazy ant	Africa	FOR	P	++	++	1
	Tapinoma melanocephalum	Ghost ant	NA	FOR	P	++	++	1
	Trogoderma granarium	Khapra beetle	India	AGR	P	++	++	1
Mollusk	*Achatina fulica*	Giant African land snail	Africa	TER	P	++	+	1
Plant	*Acacia auriculiformis*	Acacia	Australia and Pacific	FOR	Ti, Ni	P	+	1, 2, 5, 7, 9, 10
	Acacia mangium	Black wattle	Australia and Pacific	FOR	Ti, Ni	P	+	1, 2, 5, 7, 9, 10

Acanthospermum hispidum	Hispid starburr	Central and South America	AGR, WF	W, M	++	+	5, 9
Ageratum conyzoides	Billy goat weed	South America	FOR, AGR, WF	W, M	++	++	1, 2, 3, 4, 5, 9
Alternanthera flocoidea	Joseph's coat	South America	WF	W	++	+	5, 9
Atylosia scarabaeoides	Wild pigeonpea	Australia	AGR, WF	W	++	+	5, 9
Cardamine flexuosa	Wavy bittercress	Europe	AGR, WF	W	++	++	1
Cassia occidentalis	Mogdad coffee	South America	F, WF	W, M	++	+	5, 9
Cestrum diurnum	Day blooming cestrum	South America	AGR, WF	O	+	+	5, 9
Chromolaena odorata	Siam weed	South America	FOR, AGR	W, M	++	++	2, 4, 5, 6, 9
Commelina obliqua	Day flower	Java	WF	W, Fo	++	+	5, 9
Convolvulus arvensis	Binweed	Europe	WF	W	++	+	5, 9
Croton bonplandianum	Croton	South America	AGR, WF	W, M	++	+	5, 9
Cyperus rotundus	Nut grass	Africa, Europe	AGR, WF	W	++	++	1, 3
Dalbergia sissoo	Sissoo	India	FOR		P	+	1, 10
Eichhornia crassipes	Water hyacinth	South America	AQU	W	++	++	1, 4, 5
Eucalyptus camaldulensis	Eucalyptus	Australia	FOR	Ti	P	+	2, 3, 5, 7, 9, 10
Eucalyptus tereticornis	Eucalyptus	Australia	FOR	Ti	P	?	10
Eucalyptus brassiana	Eucalyptus	Australia	FOR	Ti	P	?	10
Evolvulus nummularius	Roundleaf blindweed	West Indies	AGR, WF	W	++	+	5, 9
Falcataria moluccana	Malacana koroi	Australia and Pacific	FOR	Ti, Ni	P	+	3, 10
Hyptis suaveolens	Pignut	South America	WF	W, M	++	+	2, 3, 5, 9
Imperata cylindrica	Cogon grass	North America	FOR, WF	W	++	++	7
Ipomoea carnea	Pink morning glory	South America	AQU	W, M	++	++	4, 5, 6, 9
Lantana camara	Lantana	South America	FOR	W, O	++	++	2, 3, 4, 5, 7, 9
Leucaena leucocephala	Wild tamarind	South America	FOR	Fo, Ni	++	++	1, 5, 7, 9
Limnocharis flava	Yellow burhead	South America	AQU	W	++	++	1
Ludwigia adscendens	Water primrose	Central America	AQU, AGR	W	++	+	5, 9

Mikania micrantha	Mile-a-minute weed	South America	FOR, AGR, WF	W, M	++	++	2, 3, 4, 6, 9
Mimosa pudica	Touch-me-not	South America	FOR, AGR, WF	W, M	++	++	1, 2, 3, 9
Melastoma malabathricum	Indian rhododendron	India, Japan, Australia	FOR, WF	W, M	++	+	2
Parthenium hysterophorus	Carrot grass	South America	WF	W	++	++	4
Pinus caribaea	Caribaea pine	Central America	FOR	Ti, O	P	+	7, 10
Pinus oocarpa	Pine	Central America	FOR	Ti, O	P	?	7, 10
Swietenia mahagoni	True mahogani	North America and Caribbean	FOR	Ti	P	?	2, 7, 10
Swietenia macrophylia	Mahogani	Central and South America	FOR	Ti	P	?	2, 7, 10
Salvinia molesta	Giant salvinia	South America	AQU	W	++	++	1, 7
Tectona grandis	Teak	Myanmar, India	FOR	Ti	P	+	2, 3, 7, 10
Urena lobata	Caesar weed	South America, Africa	FOR, WF	W	++	++	2
Xylia dolabriformis	Pynkado	Myanmar, India	FOR	Ti	P	?	2, 10

Table key:

Habitat type: TER – terrestrial, AQU – aquatic, AGR – agricultural, FOR – forest, WF – waste and fallow land;
Major use(s): F – food, Fo – fodder, Fu – fuel, M – medicinal, Ni – nitrogen fixation, O – ornamental, P – pest, W – weed, T – timber;
Occurrence: + - common, ++ - very common, – - rare, P – planted;
Level of invasion: + - invasive, ++ - highly invasive, ? – potentially invasive;
Source(s): 1 – GISD (2019), 2 – Uddin et al. (2013); 3 – Khan et al. (2011); 4 – Akter and Zuberi (2009); 5 – Hossain (2009), 6 – Biswas et al. (2007), 7 – Mukul et al. (2006), 8 – Barua et al. (2001), 9 – Hossain and Pasha (2001), 10 – Zabala (1990).

6. Threats from invasive alien species in Bangladesh

Invasive alien species in natural ecosystems is one of the major sources of biodiversity loss worldwide (Guido and Pillar 2017). They also disrupt native ecosystems, degrade wild habitats, and jeopardize endangered plants and animals (Early et al. 2016; Padmanaba and Corlett 2014). In natural ecosystems, the introduction of some IAS at the initial stage may although enhance primary production, some ecosystem processes (e.g. N-cycling) and services, in successive rotations, there might be a sharp fall in those services and benefits (Al-Mamun et al. 2013; Vila et al. 2011). Many invasive species also possess broad climatic tolerances and large geographic ranges, which positively influence their ability to adapt and reproduce over native species (Hellmann et al. 2008; Wittenberg and Cock 2001).

The economic loss due to IAS in the agricultural sector is well documented not only in Bangladesh but also globally. The cost associated with eradication and management of IAS in agricultural systems is huge. In forest ecosystems, fast-growing exotic species like *Acacia* sp., *Eucalyptus* sp., *Leucaena leucocephala* compete with native species for nutrition and water from the soil. Many of them also hold an allelopathic effect and suppress the development of undergrowth. Other IAS, like the Common Water Hyacinth (*Eichhornia crassipes*) is responsible for the largescale obstruction of the navigation system in country's inland water bodies (Figure 4), negatively affecting fish production and disrupt aquatic ecosystem. The feeding habit of introduced carp species in the country frequently stated for pond bank erosion, increased turbidity, and elevated nutrient concentrations. These alterations to physical and chemical conditions also have ecological consequences, such as increased phytoplankton density in response to elevated nutrient levels. These carp species compete with native fish species for natural foods, which ultimately make the local species vulnerable. Prolific breeding of species, like Tilapia (*Oreochromis mossambicus*) makes natural food unavailable to local fish species. The African Sharptooth Catfish (*Clarias gariepinus*) directly feed on native fish species thereby causing their depletion in inland water bodies.

Figure 4. The Common Water Hyacinth (*Eichhornia crassipes*) obstructing local water bodies in Bangladesh.
(Photo credit: Sharif A. Mukul)

The impacts of IAS on a country's genetic pool is also significant. Invasive alien species are known to hybridize with native species, thus altering genetic diversity and integrity of native species. Exotic species are also common pathways of transmitting disease and pathogens in the country. For example, the invasive *Argulus* sp. has been introduced with the introduction of carps in the country. It is also widely believed that the White Spot Syndrome Virus (WSSV) of Shrimp which caused a devastating fall in shrimp production and export from Bangladesh was introduced from the different stock of fish imported from neighboring countries.

7. Conclusion and recommendations

A comprehensive assessment and framework for identifying IAS are still lacking in Bangladesh. The country's extended borders and ports are largely unprotected. Enforcement of existing safeguard mechanisms, such as proper quarantine measures while importing any exotic species into the country is also weak. Conservation of biodiversity, however, is a national priority of the country, as a signatory to the United Nations Conventions on Biological Diversity (UNCBD). A statutory body consisting of local experts and standard and comprehensible procedures for the introduction, monitoring, and management of alien species in country's agriculture, forestry, and fisheries sector is indispensable. The government should also be cautious while introducing new species in the country with clear and effective quarantine regulations.

Whilst mechanical, chemical and biological control is the widely used approach for controlling invasive alien species in any invaded ecosystem, they require skilled manpower, technology, expertise, and could be extremely costly and labour intensive. Preventive measures, therefore, should be the highest priority of the country. Appropriate policies and rules must be developed to facilitate the control of IAS in the country. Community awareness and local people's involvement with relevant stakeholders should be advocated for managing IAS in country's different land-use/land cover and ecosystems. Community-based vigilance and monitoring for known pathways of introduction of IAS should also be undertaken as much as possible. In the case of transboundary landscapes and water bodies, regional cooperation must be sought for the effective management of IAS. Last but not the least, capacity building of government staffs involved in quarantine and border control must be guaranteed on a regular basis.

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