Research Article

Population Structure and Curative Uses of Invasive Plants in and around the Protected Forests of Bangladesh: A Means of Utilization of Potential Invasive Species

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Invasive plants were planted in Bangladesh to improve the stand stock quickly and meet the country's rapidly growing demand for timber. Although invasive species have negative impacts on local ecosystems, but some species are useful too. Therefore, the present study was conducted in and around two protected forests of Bangladesh to assess the status, species diversity, and curative uses of invasive plants. A total of 60 sample plots were surveyed from 5 habitat types, for example, forest, roadside, homestead, fallow land, and others. Plants uses data were collected through interviews and focus group discussions. Study recorded 43 invasive medicinal plant species belonging to 28 families, of which Asteraceae constituted the highest family importance value (21.9). Among the habitat types, fallow land (32 species) and roadside (29 species) possess the highest number of species. Based on people's perceptions, plants were categorized into three level of invasion: low (11 species), moderate (19 species), and high (13 species). The use of aerial plant parts was higher (68%) than the whole plant (17%). Consensus of local community's (ICF) was high in managing gastrointestinal (0.65) followed by respiratory (0.60) diseases. A number of biological diversity indices were applied to quantify definite diversity. Therefore, a national programme must be initiated to increased invasive plant inventory, monitoring, and research on distinguishing the harmful from the harmless species and identifying the potential uses of invasive species.

1. Introduction

The practices of plant-based traditional medicine are based on hundreds of years of belief and observations, which predate the development and spread of modern medicine [1, 2] and this knowledge has been passed on orally from generation to generation without any written document [3]. During the last few decades, the study of medicinal plants and their indigenous use in the world has been increasing and an interesting issue for the researcher and natural resource manager [4, 5]. Such type of study is important for the conservation and utilization of biological resources and found to be one of the reliable approaches to drug discovery [4, 6]. A total of 70,000 plant species have been used for medicinal purposes in the world [7] and among 6,500 species found in Asia [8]. In Bangladesh, at least 500 species of plants is commonly used as medicinal purposes [9].

The World Health Organization estimates that, in some Asian and African countries, 80% of the population depend on traditional medicines for their primary health care [10] and over 50% of the population in North America, Europe, and other industrialized countries use plants and plant extracts for their medicinal needs [11].

"An invasive (some termed as exotic/alien) species that becomes established in natural or seminatural ecosystems or habitat is an agent of change and threatens native biological diversity is termed as invasive species" [12, 13] and SCBD [14] defined invasive plants, "as the plant species introduced deliberately or unintentionally outside their natural habitats, where they have the ability to establish themselves, invade, out-compete natives, and take over the new environment". After habitat destruction and fragmentation, invasive species are known as the most important cause of biodiversity loss [15, 16] and cause considerable damage to the natural

ecosystems, also cause significant damage to human health and the economy [17–20]. Although indigenous knowledge on medicinal uses of native plants is well documented [21], very little is known about the medicinal uses of invasive plants [22].

Bangladesh, a small country, is endowed with a surprisingly rich diversity of plant species, estimated to be about 6000 including bryophytes, pteridophytes, gymnosperms and angiosperms [23]. A total of 77% of the country's population live in rural areas and almost 80% of them are dependent on medicinal plants for primary health care [24]. Bangladesh has more than 300 invasive species which grow either wild or are widely cultivated throughout the country [25]. The plantation of invasive species as introduced in Bangladesh during the British colonial period from the late 1880s to early 1890s for their aesthetic value and to meet the country's rapidly growing demand for timber (e.g., *Tectona grandis*, *Paraserianthes falcataria*, *Albizia saman*, *Xylia dolabriformis*, and *Swietenia macrophylla* etc). Later, in the 20th century this trend continued, and some Australian species (*Eucalyptus camaldulensis*, *Eucalyptus grandis*, *Leucaena leucocephala*, *Acacia mangium*, *Acacia auriculiformis*, *Pinus oocarpa*, and *Pinus caribaea*) are now dominating in all the plantation programmes and growing well in all sorts of degraded land [9, 23, 25, 26].

Invasive species in Bangladesh are dominating due to their luxuriant growth and suppress the growth of other native species and ecosystems. This results in a loss of native floral diversity of the country and is becoming a major concern among conservationists, ecologists, foresters, policy makers, and scientists for their severe biological, ecological, and socioeconomic impacts. But limited research works have been conducted on invasive plant species in forest ecosystem of Bangladesh [22, 25–39]. It is true that invasive species have negative impacts on local ecosystems [40], but not all of them are harmful. Many invasive species support our farming and forestry systems in a big way, while some invasive plants have medicinal properties, therefore, it is essential to document the curative uses of other invasive plants [22].

About 34 protected areas have been declared in Bangladesh. People living in and around the protected areas of Bangladesh rely extensively on natural resources to meet their subsistence requirements, a considerable portion of which includes medicines. This study was undertaken in two protected forests, namely, Khadimnagar National Park (KNP) and Rema-Kalenga Wildlife Sanctuary (RKWS), located in the northeastern region of Bangladesh, to document the status, diversity, and uses of invasive plant as medicinal plants. In Bangladesh various research works have been done to identify the invasive species, their extent, impact on ecosystem, and biodiversity, but no study was so far carried out solely on the population status of invasive plants species which are used as medicinal plants. The present study is aimed to assess the diversity and traditional uses of invasive plants for curative purposes. This paper further attempted to explore the used pattern of these invasive plants for health care practices through indigenous knowledge in and around KNP and RKWS of northeastern Bangladesh.

2. Materials and Methods

2.1. Case Study Sites. In the study, KNP and RKWS were selected purposively considering their unique geophysical features, richness in biological diversity and households' dependency on forest resources. KNP is located at North Sylhet Range-1 and RKWS is located at Habigonj-2 Range in Sylhet Forest Division under tropical evergreen and semievergreen biogeographic zone. Geographically KNP lies between 24°56'–24°58'N and 91°55'–91°59'E. However, RKWS lies between 24°06'–24°14'N and 91°34'–91°41'E (Figure 1) [41]. Total area of KNP and RKWS are 679 ha and 1995 ha, respectively. The hills of these areas are generally low and gently sloping. Soil ranges from clay loams to pale brown (acidic) clay loams on the hills. RKWS represents a total of 606 plant species (242 herbs, 120 shrubs, 147 trees, and 97 climbers), among them 82 have been identified as medicinal plants [42]. KNP operates on the principle of production forestry; for example, the forest was periodically clear felled and subsequently planted with valuable timber trees and other plants, but no actual floral survey information on plants is available [43]. These areas enjoy a moist tropical monsoon climate characterized by a period of high rainfall from April to September and a five-month relatively dry period from November to March. The tropical monsoon climate prevails in the area with average maximum temperature of 30.7°C and average minimum temperature of 18.9°C. The average annual rainfall is 3931 mm, most of which falls between June and September [22].

2.2. Research Methods. The present study was conducted in two phases, namely, respondent survey at the first phase and plot survey from different habitats at the second phase in the study areas. Equal numbers of respondents and sample plots were selected from two study areas. The structure of any plant community cannot be studied by observing each and every individual of plant species growing in a habitat. Therefore, rough estimates of species content in a habitat can be made by observing the plant species at different places or sample areas, in the habitat [44]. Therefore, sample plots in the study areas were selected from 5 different habitats, namely, forest, roadside, homestead (surrounding forest dwellers house), fallow land, and others (ponds, canals, water logged areas, and agricultural land).

2.2.1. Data Collection from Respondents. Interviews were conducted targeting primarily age old or local experienced persons (predominantly male (69%) and usually aged between 40 and 90 years with an average of 55 years). Total 110 respondents, 55 from each study area, were selected for interview. At the family level, informal meetings were held in the interviewee's home using the native language (Bangla), sometimes with the participation of more than one respondent together, everyone being selected randomly. The selection of respondents was purposive; we considered those who have medicinal knowledge and practices. A semistructured questionnaire and checklist for focus group discussions were arranged to collect data on curative uses of invasive

FIGURE 1: Location map of the study areas.

plant species. Respondents were also asked which plant parts were mostly used for which ailments and how they prepare medicine. Furthermore, degrees of invasiveness of invasive plants were also measured through respondents' opinion. A list of 43 invasive medicinal plants of the study area was

provided to each respondent and asked to sort these in 5 preselected categories, namely, naturalized, introduced, low level of invasive, moderately invasive, and highly invasive. Thus opinions regarding the degrees of invasiveness were taken from 110 respondents. Finally, the category that belongs

to the highest percentage for each invasive medicinal plant was set as degree of invasiveness of that particular individual. Detailed information was noted during interviews and information gaps were amended through additional visits and cross-checking. Data collected from the respondents were cross-checked through interviewing 5 *kabiraj* (local traditional healers living and working in the study areas who received training and practiced on herbal medicine).

2.2.2. Data Collection from Sample Plot. A stratified random quadrat method was used to determine the invasive medicinal plants diversity. A total of 60 samples plots (30 plots from each study area and 6 plots from each habitat) were randomly selected for the study. Circular plots of 10 m radius were used as sample plot for tree species and 2 m radius for herbs, shrubs, climbers, and grasses [45]. Circular plot was used as it minimizes the edge effect of taking sample plots. Total number of species and their individual name were collected for invasive trees, shrubs, herbs, climbers, and grasses. During the field visit, invasive species were identified using [22, 25, 30, 32, 34]. Bangla names have been well documented by Dey [46].

2.2.3. Data Analysis. Based on the information about the species, their parts used, and ailments treated, we calculated the informants' consensus factor (ICF) for each disease category and disease. ICF values were determined following Trotter and Logan [65] to evaluate local peoples' consensus on managing human ailments. The formula used to calculate these values was:

$$ICF = \frac{nuc - ns}{nuc - 1}, \quad (1)$$

where *nuc* is the number of use citations for a specific ailment and *ns* is the number of species used to treat the ailment.

The ICF is an indicative value of how consistent the informants are and the extent to which they agree about the use of plant species for treatment of a given ailment or ailment category [66]. ICF value ranges from 0 to 1. A high value (close to 1) indicates that the species are used by a large proportion of the informants indicating a consistent use of the medicinal resources.

During the present study, nine diversity and richness indices were analyzed to get a clear picture of regeneration diversity of the study areas, which was listed below.

Species diversity index was calculated according to Odum [67]:

$$SDI = \frac{S}{N}. \quad (2)$$

Species richness index was measured by Margalef [68]:

$$R = \frac{(S - 1)}{\ln(N)}. \quad (3)$$

Shannon-Wiener diversity index was calculated according to Michael [69]:

$$H = - \sum Pi \ln Pi. \quad (4)$$

Shannon's maximum diversity index was calculated according to Kent and Coker [70]:

$$H_{\max} = \ln(S). \quad (5)$$

Shannon's equitability index according to Kent and Coker [70]:

$$EH = \frac{H}{H_{\max}}. \quad (6)$$

Species evenness index was estimated following Pielou [71]:

$$E = \frac{H}{\log(S)}. \quad (7)$$

Simpson index was estimated according to Magurran [72]:

$$D = \sum Pi^2. \quad (8)$$

As biodiversity increases, the Simpson index decreases. Therefore, to get a clear picture of species dominance, the following formula was used:

$$D' = 1 - D. \quad (9)$$

Berger-Parker dominance index was calculated according to May [73]:

$$d = \frac{N_{\max}}{N}, \quad (10)$$

where *S* is the total number of species; *N* is the total number of individuals of all the species; *Pi* is the number of individuals of one species/total number of individuals in the samples.

Family importance value (FIV) index according to the formulae of Mori et al. [74]:

Family relative density (%)

$$= \frac{\text{Number of individuals in a family}}{\text{Total number of individuals}} \times 100 \quad (11)$$

Family relative diversity (%)

$$= \frac{\text{Number of species in a family}}{\text{Total number of species}} \times 100.$$

FIV is the sum of family relative diversity and relative density.

3. Results and Discussion

3.1. Invasive Medicinal Plant Composition in and around KNP and RKWS. During field investigations, a total of 43 invasive medicinal plant species belonging to 28 families were recorded, which is used for medicinal purposes by the local communities living in and around KNP and RKWS. Scientific name, local name, family, habit, main sources, parts used, ailments, and suspected origin of these species are enlisted in Table 1. Most of them belong to Asteraceae (4 species) and

TABLE 1: List of invasive medicinal plants species in and around the KNP and RKWS of Bangladesh.

Family	Local name	Life form	FIV ¹	Scientific name	Using frequency ²	Level of invasion ³	Parts used ⁴	Ailments ⁵	Suspected origin and reference(s)
Amaranthaceae	Apang	Herb	9.11	<i>Achyranthes aspera</i> L.	51	+	W	Dy, P, R, SB, SD	Exact native range obscure [47].
	Helenchia	Herb		<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	42	++	L	ED, L	Native to Brazil, Tropical Africa, and India [48–50].
Apiaceae	Thankuni	Herb	5.09	<i>Centella asiatica</i> (L.) Urban	75	+	W	CT, D, Dy, G, L	Tropics and Subtropics [48].
Apocynaceae	Kurchi	Shrub	4.42	<i>Holarrhena antidysenterica</i> (L.) Wall. ex Decne.	34	++	B, L, S	As, CW, Dy, F; SD, W	India, Myanmar, Nepal, Pakistan, and Sri Lanka [48].
Araceae	Mankacu	Shrub	4.42	<i>Alocasia macrorrhizos</i> (Lour) G. Don in Sweet	79	+	W	CW, SB	India through Southeast Asia and Pacific Islands [51].
Asteraceae	Dochondi	Shrub		<i>Ageratum conyzoides</i> L.	21	++	L	CW	Native in central and south America [48, 52].
	Asam pata	Shrub	21.9	<i>Chromolaena odorata</i> L. King & Robinson	86	+++	L	SB	Native to West Indies, tropical America, and South Asia [48, 53].
	Asam lata	Climber		<i>Mikania cordata</i> (Burm. F.) Roxb.	86	+++	W	CW, SB	South and tropical America, Tropical Asia, the Philippines, Papua New Guinea, and tropical Africa [48, 52].
	Shialmutra	Herb		<i>Vernonia cinerea</i> (L.) Less.	26	++	L, F	A, SD, R	West Indies, South America, tropical Asia, Africa, Arabia, tropical Australia, and Taiwan [48].
Athyriaceae	Dekhi shak	Herb	5.5	<i>Diplazium esculentum</i> (Retz.) Sw.	59	+++	L	D, ED, SP	India, China, Taiwan, Malaysia, the Philippines, and Papua New Guinea [54].
Caesalpinaceae	Dadmardan	Herb	9.24	<i>Senna alata</i> L.	60	++	W	A, CW, S, SD	Native of South America, Mexico, and USA [55].
	Kala kashunda	Tree		<i>Senna occidentalis</i> Roxb.	56	++	B, L, R	C, CA, D, Di, SB, SD	Native to South America and Pan tropical region [55].
Caryophyllaceae	Gima	Herb	4.28	<i>Polycarpon prostratum</i> (Forsk.)	53	++	W	D, Dy, G, Ea, F	Tropical Asia, Africa, India, Nepal, Sri Lanka, Pakistan, and European counterparts [55].
Convolvulaceae	Shornolata	Climber		<i>Cuscuta reflexa</i> Roxb.	37	++	W	F, HF, SD, R	Europe, North America, India, Sri Lanka, and Malaysia [55, 56].
	Kolmishak	Climber	17.8	<i>Ipomoea aquatica</i> Forsk.	61	+++	L, St	Co, ED, SD	Tropical Africa [50, 55].
	Misti aloo	Herb		<i>Ipomoea batatas</i> (L.) Lamk.	36	+	L, T	J, L, R	Native to America [55].
	Dudh kolmi	Climber		<i>Operculina turpethum</i> (L.) S. Manso	06	+++	T	Co	From tropical East Africa to Polynesia, Australia, and Tropical America [55].
Crassulaceae	Pathur kuchi	Herb	4.35	<i>Bryophyllum pinnatum</i> (Lamk) Oken.	56	+	L	C, JP, L, U	Pan tropical [55, 57].
Cucurbitaceae	Tela kucha	Climber	5.16	<i>Coccinia grandis</i> (L.) J. Voigt	70	++	L	Di, SD, U	Africa and Asia; India, Philippines, China, Indonesia, Malaysia, Thailand, Vietnam, eastern Papua New Guinea, and Australia [55].
Cyatheaceae	Tree fern	Shrub	3.54	<i>Cyathea brunoniana</i> (Wall. ex Hook.)	26	++	W	IB	Eastern Himalayas, Laos, South China, Vietnam, Indonesia, Thailand, and Papua New Guinea [51, 58].

TABLE I: Continued.

Family	Local name	Life form	FIV ¹	Scientific name	Using frequency ²	Level of invasion ³	Parts used ⁴	Ailments ⁵	Suspected origin and reference(s)
Cyperaceae	Mutha grass	Grass	4.55	<i>Cyperus rotundus</i> L.	18	++	T	B, D, F, W	Warmer region of the world [50, 51].
Euphorbiaceae	Bon morich	Shrub	4.42	<i>Croton bonplandianus</i> Baill.	17	+++	L, F	Aa, As, H, SD, T	Native to America [50] and Tropical and Subtropical regions [55].
Lamiaceae	Tokma	Shrub	8.63	<i>Hyptis suaveolens</i> (L.) Poit.	59	+	L, R, Fr	A, F, G, L, SD	Native to Tropical America, Africa, South Asia, and Thailand [59].
	Shetrodon	Herb		<i>Leucas aspera</i> (Wild.) Link	36	+	F, L, R	As, BF, C, Sp	Throughout the Indian subcontinent, Peninsula, Australia, Pacific Islands, naturalized in South America, and China [59].
Leguminosae	Sissoo	Tree	3.34	<i>Dalbergia sissoo</i> Roxb.	28	+	B, S	Co, S, SD, SP	India, Bhutan, Myanmar, Pakistan, Afghanistan, Iran, and Iraq [60].
Melastomataceae	Tea Indicator	Shrub	6.17	<i>Melastoma malabathricum</i> L.	41	+	L, F, B	D, Dy, SD	Southeast Asia, Malaysia, Papua New Guinea, Philippines, and North Australia [60].
Mimosaceae	Lazzabati	Herb	8.7	<i>Mimosa pudica</i> L.	44	++	W	In, J, P, S, SD	Pan tropical weed of South America [25, 60].
	Malakanna koro	Tree		<i>Paraserianthes falcataria</i> (L.) Nielson	19	+	B, L, R	ED, H, In, T	Native to Eastern Island of Indonesia, New Guinea, and Southeast Asia from Myanmar and the Philippines [60].
Myrtaceae	Eucalyptus	Tree	6.41	<i>Eucalyptus camaldulensis</i> Dehnhardt.	32	++	L, R, S	C, CA, JP	Australia [60].
	Eucalyptus	Tree		<i>Eucalyptus grandis</i> Hill & ex Maiden	17	++	L, R, S	As, C, CA, JP	Native to Australia [60].
Onagraceae	Mulcha	Climber	4.01	<i>Ludwigia adscendens</i> (L.) Hara.	26	++	W	CW, SB, SD	South America, India to Southeastern Asia, and Malaysia; Sri Lanka, China, and Australia [59].
Papaveraceae	Shialkanta	Herb	4.89	<i>Argemone mexicana</i> L.	15	++	L, St, S	H, J, SD, Sp	Tropical America and Mexico and West Indies [49, 50, 60].
Poaceae	Durba grass	Grass	5.57	<i>Cynodon dactylon</i> (L.) Pers.	100	++	W	CW, Di, SB, T	North Africa, Asia, Australia, and southern Europe [61].
Polygonaceae	Bish katali	Herb	9.51	<i>Persicaria hydropiper</i> (L.) Spach	23	+	L	A, IB, W	North America, Australia, Canada, France, and Southeast Asia [60, 62, 63].
	Bon palong	Herb		<i>Rumex dentatus</i> L.	33	+++	L, St	Aa, F, S	Russia, North Africa and Southeast Europe, and Southeast Asia [60].
Pteridaceae	Dhekia	Herb	10.4	<i>Pteris biaurita</i> L.	19	+++	L	CW, S, SB	India, West Indies, South China, Malaysia, South Africa, and Brazil [54].
	Fern grass	Herb		<i>Pteris cretica</i> L.	43	+++	L	CW, SB	Native to tropical and Subtropical regions of the world [54].
Scrophulariaceae	Brahmi shak	Climber	4.28	<i>Bacopa monniera</i> (L.) Pennel	31	++	L, S	As, HD, MD	Tropics and Subtropics [64].
Tiliaceae	Bon Ukhra	Shrub	3.81	<i>Triumfetta rhomboidea</i> Jacq.	30	+++	L	B, R	Tropical and Subtropical India, Sri Lanka, Malay Peninsula, China, Africa, and America [64].

TABLE 1: Continued.

Family	Local name	Life form	FIV ¹	Scientific name	Using frequency ²	Level of invasion ³	Parts used ⁴	Ailments ⁵	Suspected origin and reference(s)
Verbenaceae	Bhat pata	Shrub		<i>Clerodendrum viscosum</i> Vent.	22	+++	W	Ea, S, SD, W	India, Myanmar, Thailand, China, Indonesia, Sri Lanka, and the Philippines [64].
	Lantana	Shrub	16.3	<i>Lantana camara</i> L. var. aculeate (L.)	22	+++	L, St	A, JP, SB, SD	Native to Tropical and Subtropical America [40, 52, 64].
	Shegun	Tree		<i>Tectona grandis</i> L. f.	12	+++	B, F, Fr, R	Br, HF, U	Native to Myanmar and India [64].
Zingiberaceae	Bon ada	Herb	4.22	<i>Zingiber zerumbet</i> (L.) Smith	27	++	Rh	C, CA, D, Dy, T, V	India, Malaysia, Nepal, Sri Lanka, and Caribbean [61].

¹ FIV: family importance value;
² Using frequency is use percentage of invasive medicinal plants in relation to the total number of times;
³ Level of invasion (based on people's perceptions): +: low, ++: moderate, and +++: high level of invasion;
⁴ Parts used: B: barks; F: flowers; Fr: fruits; L: leaves; R: root; Rh: rhizome; S: seeds; St: stem; T: tuber; W: whole plant;
⁵ Ailments: Aa: antiallergic; A: antiseptic; As: asthma; B: body ache; BF: bone fracture; Br: bronchitis; CT: cardiac tonic; CA: cold ailments; Co: constipation; C: cough; CW: cut and wounds; D: diarrhea; Di: diabetes; Dy: dysentery; Ea: ear ache; ED: eye disease; F: fever; G: gastric pain; HF: hair fall; H: headache; HD: heart disease; In: inflammation; IB: insect bites; J: jaundice; JP: joint pain; L: liver problem; MD: mental depression; P: piles; R: rheumatism; S: scabies; SD: skin diseases; Sp: spleen disease; SP: stomach problem; SB: stop bleeding; T: teeth ache; U: urinary problem; V: vomiting; W: worms.

FIGURE 2: Level of invasiveness and habit wise species distribution.

Convolvulaceae (4 species) family followed by Verbenaceae (3 species), Amaranthaceae, Caesalpiniaceae, Lamiaceae, Mimosaceae, Myrtaceae, Polygonaceae, and Pteridaceae (2 species each) which were found to have frequent use. Each single species was found from 19 other families. Furthermore, Table 1 also shows the family importance value (FIV) index of the recorded species. The individuals number of species and FIV were greatest for the recorded family of Asteraceae (individuals 186, FIV 21.9) followed by Convolvulaceae (individuals 126, FIV 17.8), Verbenaceae (individuals 138, FIV 16.3), respectively. Other studies from across the country in the forested areas for example, Khan et al. [21], Khan et al. [22], Rahman et al. [75], Rahman and Fardusi [76], Rahman et al. [77–79], Chowdhury and Koike [80, 81], Rana et al. [82], Rana et al. [83], Mukul et al. [84], and Miah and Chowdhury [85] recorded that the species under the Apocynaceae, Araceae, Asteraceae, Combretaceae, Compositae, Convolvulaceae, Euphorbiaceae, Fabaceae, Liliaceae, Lamiaceae, Leguminosae, Papaveraceae, Rubiaceae, Rutaceae, Solanaceae, Sterculiaceae, and Verbenaceae families are frequently used as medicinal plants in Bangladesh.

The present study also explored the level of invasion (based on peoples' perception) of the invasive medicinal plants. Among the recorded species highest number of species falls under the category moderately invasive (species that are spreading but still occur at moderate densities and are considered to have some immediate problem) (19 species, 44.19%) followed by highly invasive (species that have become dominant or codominant in the invaded region and are considered a threat to the native flora and ecosystem) (13 species, 30.23%). Whereas lowest number of species belongs to the category low level of invasive (11 species, 25.58%) (species that has self-sustaining and spreading capability with no human support but not necessarily hamper other plant's growth). Among the species, 1 tree, 4 herbs, 5 shrubs, and 3 climbers species fall under the category of highly invasive; 3 trees, 7 herbs, 3 shrubs, 4 climber, and 2 grasses species are under moderately invasive category; and 2 trees, 6 herbs, and 3 shrubs species fall under the category of low level of invasive (Figure 2).

Majority of the invasive plants used by the local inhabitants as medicinal plants were herbs (17 species, 39.53%) followed by shrubs (11 species, 25.58%), climbers (7 species, 16.28%), trees (6 species, 13.95%), and grasses (2 species,

FIGURE 3: Relationship between disturbance value and survey plot in different habitats of KNP and RKWS of Bangladesh.

4.65%) in the study areas. In case of level of invasiveness, 16.67% trees are highly invasive, 50% are moderately invasive, and 33.33% are low level of invasive; among the species 23.53% herbs are highly invasive, 41.18% are moderately invasive, and 35.29% are low level of invasive; 45.45% shrubs are highly invasive, 27.27% are both moderately, and low level of invasive; and 42.86% climbers are highly invasive and 57.14% are moderately invasive, whereas 100% grasses moderately invasive.

Results also revealed that species frequency of occurrences varied according to five different habitats in the study areas. Among these 5 habitats, diversity of recorded invasive medicinal plant species was highest in fallowland (32 species) followed by roadside (29 species), forest (27 species), homestead (24 species), and others sites (17 species) accordingly. Results of this study also indicate that diversity of herbs (14 species) was highest in the fallow land followed by roadside (12 species), homestead (11 species), forest (9 species) and others (7 species); shrubs was highest in both fallow land and roadside (9 species), followed by forest (8 species), homestead (6 species), and others (5 species). Climbers was highest in the fallow land and forest (each containing 4 species); and in roadside, homestead, and others habitats containing 3 species each. However, the number of trees (5 species) was highest in the forest followed by roadside (4 species).

Various disturbances like pest and disease attack, drought, cattle browsing, human disturbance, poor drainage, low moisture, and nutrient deficiency were observed during the field survey and were scored according to their intensity. Figure 3 shows the disturbance values according to the habitats; for example, first six plots were in fallow land, next six plots were in forest, plots 13 to 18 were in roadside, plots 19 to 24 were in homestead, and 25 to 30 were in others for the both study areas. It was observed that highest disturbance score was recorded from the road side, fallow land, and others habitat in both the study areas. It is considered that invasive species can only spread into natural vegetation because of disturbance [26] thereafter this is true for present study findings. Invasive species shows three types of negative impacts with their associated species and ecosystem these are competing with indigenous plants for light, nutrients, and moisture; impede natural regeneration; and replace

indigenous plant communities [30]. The spread of invasive species is now recognized as one of the greatest threats to the ecological and economic wellbeing of the planet [86].

3.2. Notes on Plant Utilization. The survey revealed that forest dependent community used different parts of invasive medicinal plants in their health care practices. The uses of invasive medicinal plants mentioned by the respondents are presented in Table 1. Most plant parts are consumed after processing such as macerating; squeezing; grinding; blending; soaking or boiling in water, milk, or mustard oil; rubbing; or burning. Some are taken raw and some are applied externally. Both the aerial and below ground plant parts are used in health care in the study area-aerial parts 68%, whole plant 17%, and the below ground parts 15%. In some cases different parts were used for treating different ailments; in other cases, similar or different parts of more than one plant were mixed together to treat a single ailment. Leaves were the most widely used parts accounting for 37% of the reported medicinal plants, followed by whole plant (17%), root (10%), bark (9%), seeds (8%), flowers (7%), stem and tuber of each (4%), fruits (3%), and rhizome (1%) (Figure 4).

A total of 38 different ailments were found to be treated with the medicinal plants recorded. All the ailments were grouped into predefined ethnobotany categories [87], with the addition of a few others, forming nine ailment categories: ache, dermatological, faunal bite, gastrointestinal, general health, jaundice, mental, respiratory, and urinary (Table 2). Some were taken raw and some after cooking. Some were applied externally to different body parts for cuts and wounds, scabies, pain, or skin diseases. Water was mostly used to dilute the extract from the fresh plant parts. Sometimes, mustard, oil, salt, sugar, and honey were added to plant parts to make them more palatable.

3.3. Consensus on Managing Ailments among Informants. The ICF (informant consensus factor) values for the ailment categories (Table 2) indicate the degree of shared knowledge among the respondents for the treatment of ailments by medicinal plants. The greater the consensus factor the more likely that the remedy is biologically efficacious [88]. Among the ailment categories used in the present study, gastrointestinal problems scored the highest ICF value 0.65. 30% of the total species were in use for the treatment of this category that includes gastric pain, liver problem, stomach problem, and vomiting. Respiratory (asthma and cough) problems were second ICF value of 0.60 with the involvement of 11 species (25.60%) and general health category (diarrhea, dysentery, fever, stop bleeding, cold ailments, etc.) ranked third with an ICF value of 0.53; although the highest number of species (47 species), representing 105% of the total, were reported to be used in its treatment. A high consensus of sexual problems (1.00) and respiratory problems (0.56) were found at forested and nonforested regions of Bangladesh [82]; ICF value 0.92 for the treatment of jaundice was found among the Malasars community of India [89]; eczema was found highest (0.58) at Bale Mountains National Park, Southeastern Ethiopia [90], while the consensus for gastrointestinal illnesses was highest

FIGURE 4: Traditional uses of invasive medicinal plant parts in the study areas.

(0.68) among the Nahua community of Mexico [88]. There was no consensus value (0.00) among the informants in the study area for the inflammation, worms, vomiting, bronchitis, cardiac tonic, and mental depression; conceivably this was because of the easily accessible allopathic medicines available in the local pharmaceuticals shops and community hospitals in both study areas. The respondents can buy pharmaceutical medicines to provide quick pain relief cheaply, thus reducing the use of traditional remedies.

3.4. Invasive Medicinal Plants Diversity Indices. Table 3 shows the different biological diversity indices for invasive medicinal plants species status in the study areas of 60 surveyed plots. Shannon-Wiener diversity index was highest for herbs (2.75) followed by shrubs (2.40), climbers (1.91), trees (1.76), and grasses (0.68), while Shannon's maximum diversity index was highest for herbs (2.77) followed by shrubs (2.48). Shannon's equitability index was highest for herbs (0.99) followed by climbers, grasses, and trees (0.98) each, respectively. Species diversity index was calculated highest for trees (0.06) followed by herbs, shrubs, and climbers jointly (0.03), respectively. The value of species richness index was estimated higher for herbs (2.35); similarly evenness index was highest for herbs (2.29). However, Simpson index was found higher for grasses (0.5) followed by trees (0.18). The calculated value of evenness index that are almost similar for each category and index of dominance of the study areas revealed that the total number of individuals are more evenly distributed among all species present at the two study sites. Rahman et al. [91], Rahman et al. [92], and Top et al. [93] believed that the higher the value of diversity, the greater the stability of community will be.

3.5. Berger-Parker Dominance Index. It is simple measure of the numerical importance of the most abundant species. This index indicates that an increase in the value of the index accompanies an increase in diversity and a reduction in dominance. We calculated the Berger-Parker dominance index of the invasive medicinal plants species of the study areas. In case of herbs the dominant species is *Pteris cretica* (0.09), *Chromolaena odorata* (0.13), *Mikania cordata* (0.21),

TABLE 2: Ailment categories and degree of local communities' consensus on managing ailments in and around KNP and RKWS, in Bangladesh.

Ailments category	Biomedical term	^a Number of plants species	^a Percentage of total species	^b ICF
Ache			53.50	0.52
	Body ache	2		0.28
	Bone fracture	1		0.39
	Ear ache	2		0.43
	Headache	3		0.50
	Inflammation	2		0.00
	Joint pain	4		0.63
	Rheumatism	5		0.43
	Teeth ache	4		0.40
Dermatological			90.70	0.42
	Antiallergic	2		0.54
	Antiseptic	5		0.56
	Cut and wounds	9		0.27
	Scabies	6		0.62
	Skin diseases	17		0.54
Faunal bite			14.00	0.50
	Insect bites	2		0.62
	Worms	4		0.00
Gastrointestinal			30.20	0.65
	Gastric pain	3		0.29
	Liver problem	5		0.43
	Stomach problem	2		0.33
	Vomiting	1		0.00
General health			105.00	0.53
	Bronchitis	1		0.00
	Cardiac tonic	1		0.00
	Cold ailments	4		0.50
	Constipation	3		0.33
	Diarrhea	7		0.33
	Dysentery	6		0.50
	Eye disease	4		0.40
	Fever	6		0.58
	Hair fall	2		0.46
	Heart disease	1		0.37
	Piles	2		0.56
	Stop bleeding	10		0.59
Jaundice		3	6.98	0.50
Mental			6.98	0.33
	Mental depression	1		0.00
	Spleen disease	2		0.40
Respiratory			25.60	0.60
	Asthma	5		0.20
	Cough	6		0.38
Urinary			14.00	0.50
	Diabetes	3		0.33
	Urinary problem	3		0.50

^aSum exceeds total as in use to treat more than one category; ^bICF (informant consensus factor).

TABLE 3: Biological diversity indices for invasive medicinal plants status in KNP and RKWS, in Bangladesh.

Species category	Diversity index*							
	H	$H_{\max}$	E_H	SDI	R	E	D	D'
Herbs	2.75	2.77	0.99	0.03	2.35	2.29	0.1	0.94
Shrubs	2.40	2.48	0.97	0.03	1.79	2.23	0.1	0.9
Climbers	1.91	1.95	0.98	0.03	1.09	2.27	0.15	0.85
Grasses	0.68	0.69	0.98	0.02	0.23	2.25	0.5	0.48
Trees	1.76	1.79	0.98	0.06	1.08	2.27	0.18	0.82

* H : Shannon-Wiener diversity index, $H_{\max}$: Shannon's maximum diversity index, E_H : Shannon's equitability index, SDI: species diversity index, R : species richness index, E : species evenness index, D : Simpson index, D' : dominance of Simpson index.

Cynodon dactylon (0.59), and *Tectona grandis* (0.24) for shrubs, climbers, grasses, and trees, respectively.

4. Conclusion and Strategy to Utilize the Potential of Invasive Species

In the last decade medicinal plants for healthcare have received much attention from researchers and development workers for their perceived socioeconomic importance and potential, particularly in developing countries. Though the invasive species have some detrimental impacts on ecosystem worldwide, local people living in and around the KNP and RKWS use these species as medicinal plants since time immemorial. They believe that plants are always useful for different purposes; medicinal use is one of them. This indigenous knowledge regarding invasive medicinal plants passes through from generation to generation. Our study fairly accurately represents the local healthcare practice through locally available invasive medicinal plants in the study areas. The using pattern of invasive plants documented in this paper may be helpful for other people to use these plants in their traditional healthcare practices which may minimize the pressure of using native medicinal plants.

To utilize the potential of invasive species, first potential threats of each invasive species should be identified and recorded; then develop an invasive plant strategy to minimize the long-term impacts on habitat and biodiversity. Useful invasive species can be commercially harvested in a sustainable way that does not hamper the native species plus a proper marketing channel can play important role in this case. Local community can involve in this opportunity as a worker, manager as well as buyer and seller thus they can earn money from this and would be a great scope to reduce their poverty level. The study concluded that a national programme must be initiated to increased invasive plant inventory, monitoring, research, and distinguish the harmful from the harmless plant species and to identify the use and impacts of the invasive species. As well as active government support and coordinate planning and management activities with other agencies, stakeholders are needed for the sustenance of the medicinal plants based industry in a changing global perspective and creating more awareness and introducing the medicinal plants through annual enrichment of forest plantations could positively affect the country's declining stock of such plants.

Conflict of Interests

The authors declare that they have no conflict of interests.

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