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ETHNOMEDICINAL PLANT DIVERSITY IN BADALCHORI VADI SORA VILLAGE COMMON FOREST OF RANGAMATI, BANGLADESH

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Abstract

A total of 209 species were documented where 181 species were used against 379 diseases/ailments from a village common forest of Rangamati, Bangladesh. Leaves were reported as most utilized plant part while herbs were dominant. Diversity indices revealed that the study area was rich in diverse medicinal plants. Collected voucher specimens were deposited in the Chittagong University Herbarium with an accession number.

Introduction

Tropical evergreen forest constitutes approximately 52% of the world's forest regarding the conservation of biodiversity (Anbarashan and Parthasarathy, 2013; Baithalu *et al.*,2013). Moreover, there are also evidence that it might play a significant role in keeping global warming under 2^{o}C in line with the Paris Agreement on Climate Change (Griscom *et al*., 2017). However, because of overpopulation, rising biotic and abiotic disturbances, forests throughout the world are deteriorating into fragmented marshland and grassland resulting in biodiversity loss (Lindenmayer, 2009; Uddin *et al*., 2019).

Bangladesh is a tropical land with natural forests 84% and 16% plantation, making up 2.253 million hectares of forest area with many forest kinds and notably wetlands, evergreen, semi-green, moist lagoon and mangrove forests (Jannat *et al*., 2018). Of them, Chittagong Hill Tracts (CHT) is the most biologically diverse place in the country, which covers 40% forest land and ensures 80% of the total biodiversity of the country (Mukul *et al*., 2012; Rahman *et al*., 2016). The indigenous communities of CHT have planned conserving their precious natural wealth according with their traditional strategy to resource management, called Mouza Reserves or Village Common Forest (VCF) (Chowdhury *et al*., 2019). This community based forest management such as VCF has mounting evidence of better management practices than public sector or government institutions facilitate by mutual interaction of developing organizations and researchers with lesser law enforcement agencies involvement (Balooni and Inoue, 2007; Santika *et al*., 2017; Vickers, 2017).

Village Common Forests (VCF) are naturally rejuvenated, small forests with an extent between 20 and 120 acres that are commonly referred to as Para bon, Mouza bon, Reserve or Mouza reserve. The number of VCFs in the CHTs remained disputed, although it was found to be between 300 and 800 in literature (Islam *et al*., 2009; Saha, 2010). Where, each Mouza has a

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headman who was portrayed with management of the Mouza according to of 1900's CHT regulation (Uddin *et al*., 2020). Indigenous people have deeper relationship with this Mouza management from time immemorial in a margin of 200 long more year times. From ancient era, this underprivileged people also profoundly reliable on forest resources for their medication system, yet they continue to be diagnosed with many of the most lethal diseases using natural resources. Several scholarly papers and recent research have mirrored these healthcare principles. For example, to cure 98 maladies, one study quantified 159 medicinal plants in 18 distinct locations of the Bandarban area, organized into 132 genera and 62 families (Faruque *et al*., 2018). Another research found that the Pangkhua people of Rangamati district targeted 117 plant species from 104 genera and 54 families as part of their remedial healthcare system (Faruque *et al*., 2019). 40 medicinal plant species belonging to 29 families were utilized by the Murong people of Khagrachari region to cure a wide range of illnesses (Kabir and Saha, 2014). Modern approaches have verified most of those uses, and some of them have gone through clinical trials to be used in current healthcare. More precisely, as compared to the present pharmaceutical system's "one target and one drug" strategy, this plant-based therapy has synergistic effects of 'multi-target and multi-drug' benefits (Guo *et al*., 2019; Rudra *et al*., 2020). As reflection those efficacies, these indispensable plants are conserved in their territory or surrounding areas or in VCF for their existence. But unfortunately, as a result of shifting cultivation and over-exploitation caused soil erosion, the government's strategy of settling lowland or plain land settlements, community ignorance and the disintegration of the traditional system; the quantity and quality of VCF has declined over time (Halim, 2007; Jashimuddin and Inoue, 2012). However, some of the light of successful VCF practices for the conservation of endangered species have been reported in China and Ethiopia namely village *fengshui* forest and Church forest (Hu *et al*., 2011; Wassie *et al*., 2010). Additionally, fresh water abundance, medicinal plants, timber, bamboo and cultural beliefs are some of the elements driving the preservation of VCFs (Baten *et al*., 2009).

Taken together, we aim to provide a thorough documentation of the ethno-medicinal uses of medicinal plants found in VCFs in CHTs, and to determine the phytosociological diversity indices of those documented plants.

Methodology

Study area

A VCF, Badalchori Vadi Sora under upazilla Barkal in Rangamati district at Bangladesh, is selected for the phytosociological diversity analysis of medicinal plants that traditionally used by ethnic people as their primary healthcare management (Fig. 1). Rangamati is home for a number of indigenous group namely Chakma, Marma, Tanchangya, Tripura, Chak, Khumee, Luchei, Pankhoa, Riang, Khumi, Mro, Santal, Monipuri, Bome, Kheyang, Murang and others that constitutes 59.76% of total population where density of population is 101 per km^2 (BBS, 2011). This district climatological properties is differ than country's other district due to its geological position, whereas the temperature range from 34.6^0C to 13.4^0C with 3031mm of annual rainfall (Khatun *et al*., 2016). This VCF located in the south-eastern part of Bangladesh at 22° 56′ 1.386″N 92° 17′ 10.692″ E co-ordinates in Rangamati.

Study framework and ethnobotanical documentation

The diversity of ethno-medicinal plants was determined through quantitative analysis by stratified random sampling plots. Phytosociological characters of ethno-medicinal plant species were evaluated by using different quantitative indices. A semi-structured questionnaire was adopted to collect ethnobotanical information from informants. For the assessment of the

medicinal plants, stratified random sampling method was adopted. The VCF was split into three segments depending on three topographical placement categories namely bottom, mid, or top slope, and from each location five plots were selected. A total of 15 plots were generated in Badalchori Vadi sora VCF with 10 m × 10 m quadrat plot size. We studied a 'Dictionary of Plant

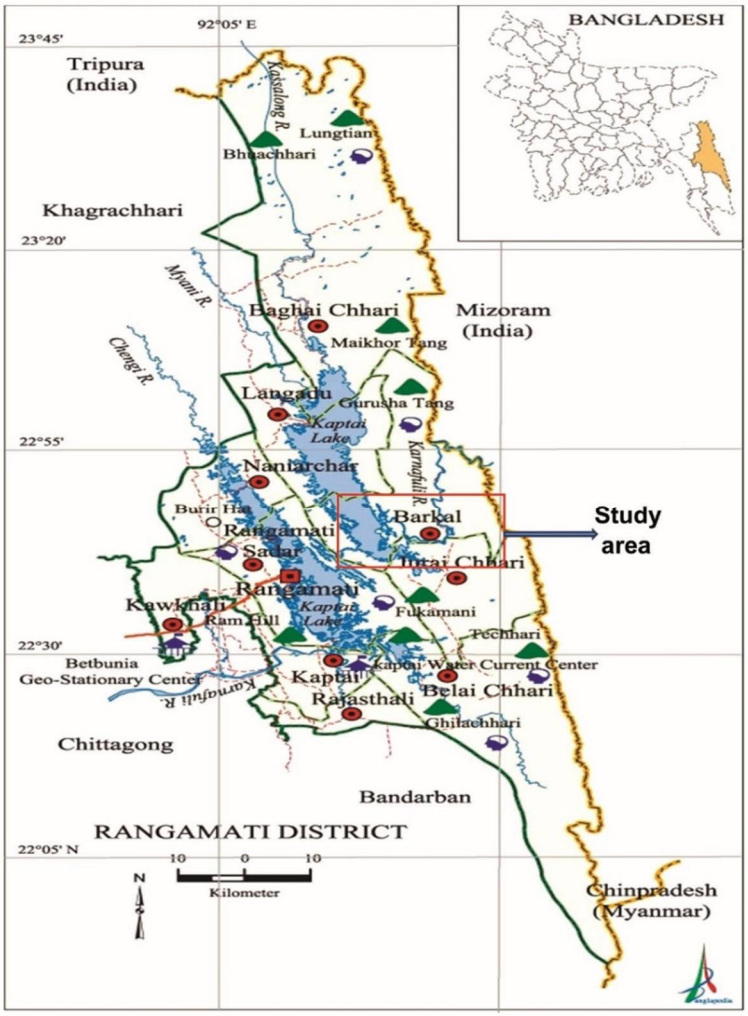

Fig. 1. Map of the study area.

Names of Bangladesh' book and <www.plantlist.org> to examine plant nomenclature of the recorded species (Pasha and Uddin, 2013). In collaboration with local guides and a taxonomist, all the plant species were recognized along with plant habit types were scrupulously documented. Communities were interviewed in clusters or personally for ethnobotanical documentation followed by semi-structured question technique, and local kabiraj or boiddha (traditional healers) were tracked down to gather published pamphlets and therapeutic information regarding plants.

Market and checklist interview were therefore conducted to validate the precision of documentation delivered by the community members, as well as herbalists. The survey was directed from January, 2019 to November, 2019.

Analytical framework for VCF

Badalchori Vadai Sora VCFs were used to construct phytosociological characteristics and diversity matrices for each of the 15 plots. A number of phytosociological characteristics were computed. These included relative density (RD), relative frequency (RF), relative abundance (RA), and important value index (IVI). For determining the abundance, evenness, and richness of the species in the intended VCF study area, we considered four formulae related to diversity indices namely Shannon-diversity Wiener's index (H), Simpson's diversity index (D) and the species evenness index (E) (Table 1**).** Upon authentication, all plant species from the studied region were culled and processed for herbarium specimen following standard herbarium protocol and a voucher specimen of that species deposited in the Chittagong University Herbarium (CTGUH) across an accession number for future reference.

Table 1. Statistical formula for phytosociological characteristics determinants and diversity indices.

Attributes	Equations	Citations	Variable interpretation
Frequency (x)	$x=\frac{c}{b}$	(Rudra *et al.*, 2021)	a= Number of members of a certain species in each plot
Abundance (y)	$y=\frac{a}{c}$	(Rudra *et al.*, 2021)	b = the total number of plots examined
Relative Density (RD)	$RD = \frac{n}{N} \times 100$	(Dallmeier *et al.*, 1992)	c=total number of plots where the species is found.
Relative Frequency (RF)	$RF = \frac{Xi}{\sum Xi} \times 100$	(Dallmeier *et al.*, 1992)	n=A species' population size is in number
Relative Abundance (RA)	$RA = \frac{yi}{\sum yi} \times 100$	(Shukla and Chandel 2000)	N=total number of individuals of all the species
Importance Value Index (IVI)	IVI = RD + RF + RA	(Rudra *et al.*, 2021)	P = n/N
Shannon-Weiner diversity index (H)	$H = -\sum Pi (\ln Pi)$	(Hill, 1973)	S = total number of species
Simpson diversity index (D)	$D = \sum Pi2$	(Colwell, 2009, Colwell *et al.*, 2012)	
Species evenness index (E)	$E = \frac{H}{\log(S)}$	(Pielou, 1966)	

Results and Discussion

Biodiversity and their uses medicinal plants

A thorough out exploration of Badalchori Vadi Sora revealed the presence of a huge number of diversify medicinal plants with enlisting their uses as remedial to variable ailments. A total of 209 plant species were documented from the studied area. Of them, medicinal plant species were 181 species divided into 145 genera and 65 families. Their phytosociological attributes notably relative density (RD), relative frequency (RF), relative abundance (RA) and importance value index (IVI) as well as plants conservation status, habits, plant parts used for the treatment and their application was elucidated in Table 2.

Table 2. Enumeration of medicinal plant species identified from Badalchori Vadi Sora Village Common Forests (VCFs) in Rangamati District, Chittagong Hill Tracts, Bangladesh.

Scientific Name, Family, Habit, Accession No. Bangla name	Vernacular name	RD	RF	RA	IVI	Status**	Ethno-medicinal value
Abelmoschus moschatus Medik. Malvaceae-S CUHB 021 Mushakdana	Huney gach (Ch)	0.73	0.53	0.98	2.25	NE	Urinary trouble, itches, anemia, asthma, cold fever, cough, embryopathy, headache, pneumonia, tonsillitis
Achyranthes aspera L. Acanthaceae-S CUHB 025 Apang	Uvolengra (Ch)	1.25	1.07	0.83	3.15	NE	Gastritis, pneumonia, in bites of poisonous animal, jaundice, urinary trouble, abortion, Asthma, carbuncle, bronchitis, constipation, cough, diabetes, epistaxis, gastric tumor, gout, gynecological disease, hook worm infestation, hysteria, ill health, lipoma, liver cancer, lumps in the throat, painful micturition, pneumonia, respiratory troubles, steatorrhea, tuberculosis
Acmella alba (L'Hér.) R.K.Jansen asteraceae-H CUHB 023 Sada acmellara	Hada ajon-sag (Ch)	0.37	0.27	0.98	1.61	NE	Toothache, throat and dental infections, leucorrhoea
Actephila excelsa (Dalzell) Müll.Arg. Phyllanthaceae-T CUHB 024 Lalsa	Saitalofang (Ch)	0.04	0.27	0.1	0.4	LC	Abortion, fever, indigestion
Adiantum philippense L. Adianthaceae-H CUHB 022 Kalijhat	Kalijhat	5.62	2.13	1.87	9.63	NE	Febrile convulsion, lipoma, ophthalmia, dysentery, ulcers, erysipelas, burning sensation, epileptic fits, strangury, fever
Ageratum conyzoides (L.) L. Asteraceae-H CUHB 026 Fulkuri	Monimuizza Kher (Ch)	0.88	0.53	1.17	2.59	NE	Dysmenorrhea, leishmaniasis, stops bleeding, fever, epistaxis, malaria, hyperacidity, bruise, eczema, gastric ulcer, headache, hysteria, jaundice, leucorrhoea, tumor dysmenorrhea, piles, cough, sterility, vertigo, gastritis
Albizia chinensis (Osbeck) Merr. Mimosaceae-T CUHB 035 Chakua koroi	Sakko gach (Ch)	0.07	0.53	0.1	0.7	NE	Menostaxis, cuts, scabies, skin diseases
Albizia procera (Roxb.) Benth. Mimosaceae-H CUHB 029 Jat koroi	Choipang (Ma)	0.29	0.27	0.78	1.34	LC	Insecticide, ulcers, intestinal worms, anal fissure, leprosy
Alocasia cucullata (Lour.) G.Don Araceae-H CUHB 030 Bishkachu	Bijkachu (Ch)	0.11	0.27	0.29	0.67	NE	Abdominal pain, asthma, colic, gastric tumor, leukoderma, paralysis, rheumatism
Alpinia malaccensis (Burm.f.) Roscoe Zingiberaceae-H CUHB 031 Amli elach	Bringblei (Tr)	0.7	0.27	1.86	2.82	DD	Sores, stomachache, indigestion
Alpinia nigra (Gaertn.) B.L.Burtt Zingiberaceae-H CUHB 032 Tara	Krenga (Ch)	1.25	0.8	1.11	3.16	LC	Vomiting, jaundice, gastric ulcers, lumbago, rheumatism, bronchitis, dyspepsia, impotence
Alpinia zerumbet (Pers.) B.L.Burtt & R.M.Sm. Zingiberaceae-H CUHB 033 Bara elachi	Kom hing (Mu)	1.03	1.87	0.39	3.3	DD	Rheumatic pain, fever

Scientific Name, Family, Habit, Accession No. Bangla name	Vernacular name	RD	RF	RA	IVI	Status**	Ethno-medicinal value
Alstonia scholaris (L.) R. Br. Apocyanaceae-T CUHB 034 Satim	Sesna (Ch)	0.29	0.27	0.78	1.34	LC	Jaundice, dysentery, gallstone, helminthiasis, paralysis ulcers, rheumatism, constipation, lipoma, remitting fever, stomachache, rheumatoid arthritis,
Amischotolype mollissima (Blume) Hassk. Commelinaceae-H CUHB 027 Molisima	Boro annul ludi (Ch)	0.07	0.27	0.2	0.54	NE	Malarial fever, epilepsy, hyperacidity, traumatic injury
Amomum aromaticum Roxb. Zingiberaceae-H CUHB 036 Lobongo elachi	Pada gro (Ma)	0.11	0.27	0.2	0.67	NE	Shoulder ache, enteric disease, intestinal difficulties, indigestion, vomiting, biliousness, bowels
Amomum subulatum Roxb. Zingiberaceae-H CUHB 037 Barolock	Dhewtara (Ch)	0.29	0.53	0.39	1.22	DD	Cough, vomiting
Amorphophallus bulbifer (Roxb.) Blume Araceae-H CUHB 038 Jongle-ol	Chung-moro (Ma)	0.26	0.53	0.34	1.13	NE	Insect bite, warts
Angiopteris evecta (G.Horst)Hoffn. Marattiaceae-F CUHB 039	Baro dheki gaith (Ch)	0.07	0.27	0.2	0.54	NE	Carbuncle, lipoma, liver cancer, seminal emission, foot wound, arthritis, blood cancer, beriberi
Angiopteris helferiana C.Presl Marattiaceae-F CUHB 078 Raj dheki	Dheki gaith (Ch)	0.07	0.27	0.2	0.54	NE	Dysentery, infection, scabies, muscle pain
Antidesma bunius (L.) Spreng. Euphorbiaceae-S CUHB 079 Banshialbuka	Gang prejang (Ch)	0.15	0.53	0.2	0.88	LC	Heart disease, coughs, syphilis, gonorrhea, high blood pressure
Aphanamixis polystachya (Wall.) R.Parker Meliaceae-T CUHB 080 Pitraj	Okhyyang (Ma)	0.07	0.27	0.2	0.54	LC	Astringent, liniment, rheumatism, tumor, abdominal complaints, spleen in liver, ulcers
Ardisia colorata Roxb. MYRSINACEAE-H CUHB 081 Bangla oak	Nagal-sun-born (Ma	0.44	0.53	0.59	1.56	NE	Diarrhoea, cough, poultice for rheumatism or lumbago, liver diseases
Argyreia splendens (Roxb.) Convolvulaceae-C CUHB 082 Chottorupatola	So Kra Pong (Ma)	0.29	0.53	0.39	1.22	NE	Ulcers, rheumatism
Aristolochia tagala Cham. Aristolochaceae-C CUHB 083 Harin-kan shak	Paranga ludi (Ch)	0.07	0.27	0.2	0.54	NE	Abdominal pain, Rheumatic pain, tumors, fever, dysentery, snake bite, traumatic pain
Baccaurea ramiflora Lour. Euphorbiaceae-T CUHB 084 Lotkon	Kusumgula (Ch)	0.07	0.53	0.1	0.7	NE	Gastric ulcer, diarrhea, jaundice, ureterolithiasis, flatulence
Bambusa bambos (L.) Voss Poaceae-H CUHB 085 Kanta bans	Bhaijjya bacchuri (Ch)	1.03	0.53	1.37	2.93	NE	Laxative, diseases of blood, leukoderma, inflammation, strangury, cough, cold, consumption, asthma, emmenagogue, bleeding
Begonia roxburghii (Miq.) A.DC. Begoniaceae-H CUHB 086 Gonirakto	Khartetoi (Ch)	0.74	0.53	0.98	2.25	NE	Tongue abnormalities, Jaundice, dysentery

Scientific Name, Family, Habit, Accession No. Bangla name	Vernacular name	RD	RF	RA	IVI	Status**	Ethno-medicinal value
Blumea lacera (Burm.f.) DC. Asteraceae-H CUHB 087 Barakukshima	Monimujja kher (Ch)	0.11	0.27	0.29	0.67	NE	Rheumatism, bone fracture, dropsy, cholera, fever
Boehmeria nivea (L.) Gaud. Urticaceae-S CUHB 130 Kankhura	Urmuru gaith (Ch)	1.95	2.4	0.58	4.92	NE	Wound, septic abscess
Bombax ceiba L. Bombaceae-T CUHB 131 Shimul	Lakh Pine (Ma)	0.04	0.27	0.1	0.4	LC	Leucorrhoea, fever, diarrhoea, dysentery, menorrhagia and cough, biliousness, impotence, emetic
Bridelia stipularis (L.) Blume Euphorbiaceae-T CUHB 132 Harinhara	Bangaribhanga gaas (Ch)	0.44	1.07	0.29	1.8	LC	Allergies, amoebic dysentery, chest pain, constipation, diarrhoea, leukoderma, strangury
Brownlowia elata Roxb. Tiliaceae-T CUHB 133 Moss	Mos gach (Ch)	0.07	0.53	0.1	0.7	NE	Poisonous insect sting, diarrhea, syphilis
Byttneria pilosa Roxb. Sterculiaceae-C CUHB 134 Harjora lata	Ludi sola (Ch)	0.68	0.8	0.55	1.98	NE	Bone fracture, boils, scabies, dandruff, lice infestation, rheumatalgia, snake bite, syphilis
Caesalpinia digyna Rottler Caesalpiniaceae-C CUHB 135 Kochoi	Ketrang shak (Ch)	0.26	0.53	0.34	1.13	NE	Phthisis, scrupulous affections, conjunctivitis, lipoma
Callicarpa arborea Roxb. Verbenaceae-T CUHB 136 Bormala	Banitak (Ch)	0.07	0.53	0.1	0.7	LC	Diarrhoea, bone fracture, worm, gout, epilepsy, fever, gingivitis, ill health, malaria, menorrhea, rheumatism
Cayratia trifolia (L.) Domin Vitaceae-S CUHB 137 Amol lata	Lodi mallang (Ch)	0.07	0.27	0.2	0.54	NE	Heart disease, abdominal pain, fever
Cheilocostus speciosus (J.König) C.Specht Costaceae-H CUHB 138 Kemak	Ketoki (Ch)	1.62	2.13	0.54	4.29	LC	Boils, paralysis, seminal emission, headache, osteoarthritis, stomachache, itch, snake bite, skin diseases, contraceptive, otitis, rabies, stomachache, jaundice, menstrual disorder, urinary inflammation, paralysis, fever, cough, dyspepsia, worms, skin diseases, rheumatism, food poisoning,
Chromolaena odorata (L.) R.M.King & H.Rob. Asteraceae-S CUHB 139 Assamlota	Mugujuher (Ch)	0.74	0.53	0.98	2.25	NE	Cut, general weakness, wound, gastric ulcer, bleeding, narcotic, influenza, flatulence, fever, diabetes, poisonous insect sting, painful micturition
Cissus javanica DC. Vitaceae-C CUHB 140 Rangila lata	Sugor amila (Ch)	0.07	0.27	0.2	0.54	NE	Boils, flatulence, liver cancer, mental disorder, snake bite
Cissus pentagona (Roxb.) Lawson Vitaceae-C CUHB 141 Panchkona lata	Harsanga (Ma)	0.66	0.53	0.88	2.07	NE	Skin disease, elephantiasis, filaria
Clerodendrum viscosum Vent. Verbenaceae-S CUHB 142 Ghelu bhat	Bake pata (Ch)	1.87	1.33	0.997	4.2	NE	Stomachache, dysentery, diarrhea, abdominal pain, jaundice, scabies, toothache, gastric ulcers

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Colocasia esculenta (L.) Schott Araceae-H CUHB 143 Kochu	Billo hugu (Ch)	6.32	2.13	2.1	10.6	LC	Bleeding, bone fracture, poisonous insect sting, tonsillitis, styptic, stimulant, rubefacient, athlet's foot, bleeding from cuts, tumours, ulcerated polyp, cancer of nose and warts, laxative, piles, congestion of the portal system and alopecia
Commelina benghalensis L. Commelinaceae-H CUHB 006 Dholpata	Batbattey shak(Ch)	0.74	0.27	1.95	2.96	LC	Blistery, demulcent, refrigerant, laxative, emollient, leprosy, otitis media suppurativa, sores, snake-bite
Commelina diffusa Burm.f. Commelinaceae-H CUHB 007 Monayna kanshira	Kanaiya aga (Ma)	0.55	0.27	1.46	2.28	LC	Anemia, boils, carbuncle, hordeolum, emetic, laxative, itchy spots, sores, swellings, burns, itches, leucorrhoea, urinary burning, cold, ulcer, gonorrhea
Commelina erecta L. Commelinaceae-H CUHB 00 Pitagola (Ch)8 Khata jatkhanshira	Haniya ludi (Ch)	0.37	0.27	0.97	1.61	LC	Acne, otitis media, rheumatic arthritis, scabies, weight loss
Crateva magna (Lour.) DC. Capparaceae-T CUHB 011 Bonna	Pitagola (Ch)	0.07	0.53	0.1	0.7	NE	Kidney and bladder stones, lipoma, asthma, cirrhosis, jaundice, piles, rheumatism, stomachache, fever, cholagogue, paralysis, demulcent, fever, vomiting.
Curculigo orchioides Gaertn. Liliaceae-H CUHB 009 Talamuli	Tam hap-cha (Mu)	4.56	2.13	1.51	8.2	NE	Snake bites, menorrhagia, bitter, tonic, alterative, restorative, dysuria, leucorrhoea, menstrual derangements, piles, jaundice, ophthalmia, indigestion, aromatic, diarrhoea, diuretic, appetizer, colic, pain in the joints, demulcent, gonorrhea, skin diseases, asthma, whitlaws, sexual debility, useful in bronchitis
Curcuma aromatica Salisb. Zingiberaceae-H CUHB 010 Jongli haldi	Bon owldi (Ch)	0.11	0.27	0.29	0.67	NE	Tonic, carminative, appetizer, anthelmintic, blood purifier, applied to bruises, sprains, small pox, headache
Cyanthillium patulum (Dryand. ex Dryand.) H.Rob. Asteraceae-H CUHB 012 Kukurshunga	Dando uppon (Ch)	0.51	0.27	1.36	2.15	NE	Conjunctivitis, asthma, diarrhea, herpes, fire burning, poliomyelitis, tetanus, tonsillitis, colic, gout, hysteria, liver cancer, meningitis, otitis media
Cyathea gigantea (Wall. ex Hook.) Holttum Cyatheaceae-H CUHB 013 Baro brikkha fern	Not known	0.29	0.27	0.78	1.34	NE	Blood clotting, microbial infection, abscess formation
Cymbidium aloifolium (L.) Sw. Orchidaceae-E CUHB 014 Tosabak	Surimas (Ch, Ta)	0.11	0.27	0.29	0.67	NE	Jaundice, cut injury, lesion, tetanus, boils, gout, otitis media, febrifuge
Dalbergia volubilis Roxb. Fabaceae-S CUHB 015 Ankilata	Dandauphal (Ch)	0.51	1.07	0.34	1.92	NE	Skin disease, urinary trouble, aphthae, sore throat, gonorrhoea, gastritis
Dendrobium aphyllum (Roxb.) C.E.C.Fisch. Orchidaceae-E CUHB 016 Fasiariam	Layning (Ch)	0.11	0.27	0.29	0.67	LC	Abnormal head structure, gout, rheumatism

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Desmodium motorium (Houtt.) Merr. Fabaceae-S CUHB 017 Gorachand	Tardirmaton (Ch)	0.04	0.27	0.09	0.4	NE	Measles, rheumatism, paralysis
Desmodium gangeticum (L.) DC. Fabaceae-S CUHB 018 Chalani	Bormajal (Ch)	0.55	0.27	1.46	2.28	NE	Tumors, worm, skin disease, burning sensation, headache, mental disorder, oedema, asthma, piles, fever, typhoid, bronchitis, dysentery, diarrhoea, biliousness, cough
Desmodium heterocarpon (L.) DC. Fabaceae-S CUHB 019 Karpo modi	Koo-shey-dung (Ra)	0.44	0.27	1.17	1.88	NE	Fainting, convulsion, tonic, cough, Bone fracture, gastric tumor, hysteria, rheumatism
Desmodium triflorum (L.) DC. Fabaceae-S CUHB 020 Kataliya	Bormajal (Ma)	0.44	0.27	1.17	1.88	NE	Jaundice
Desmos chinensis Lour. Annonaceae-T CUHB 051 Sotoyalang	Epey harang (Ch)	0.07	0.53	0.09	0.7	NE	Vertigo, diarrhea, dysentery
Dicliptera bupleuroides Nees Acanthaceae-H CUHB 052 Klitera	Kaladharu (Ch)	0.51	0.27	1.36	2.15	NE	Gout, rheumatism, tuberculosis
Dillenia indica L. Dilleniaceae-T CUHB 053 Chalta	Ulu (Ch)	0.04	0.27	0.09	0.4	LC	Cough, cold, dyspepsia, fever and purgative, lipoma, diarrhoea, dysentery, astringent, abortion, hair fall, spermatorrhoea, general weakness, septic sore, traumatic injury, food poisoning
Dioscorea bulbifera L. Dioscoreaceae-C CUHB 054 Banalu	Mo alu (Ch)	0.85	1.07	0.56	2.47	NE	Vasicatories, bronchitis, tonic, diarrhoea, stomachic, expectorant, anthelmintic, piles, dysentery, asthma, astringent to the bowels, dyspepsia, syphilis, urinary discharges, leukoderma, aphrodisiac, ulcers
Dioscorea pentaphylla L. Dioscoreaceae-C CUHB 055 Jum alu	Jhunjhuma lata (Ch)	0.33	0.53	0.44	1.3	NE	Rheumatism, pains, jaundice, tonic, swelling, lice, dropsy, anasarca
Dipterocarpus turbinatus C.F.Gaertn Dipterocarpaceae-T CUHB 056 Garjan	Var-lawng (Lu)	0.07	0.53	0.09	0.7	VU	Jaundice, carbuncle, tetanus, pyemia, lesion, fever, otitis media, cut injury
Eclipta prostrata (L.) L. Asteraceae-H CUHB 057 Kesuti	Kalahuna (Ch)	0.51	0.27	1.36	2.15	LC	Brain and hair tonic, Female disease, rheumatic fever, boils, jaundice, burning wound, foot mud sore, gout, irregular menstruation, leprosy, pneumonia, vertigo, bronchitis, asthma, leukoderma, anemia, itching, night blindness
*Elatostema sesssi*le J.R.Forst. & J.G.Forst. Urticaceae-S CUHB 058 Sessijhara	Shilajhar (Ch)	0.11	0.27	0.29	0.67	NE	Abdominal disorders, body ache, boils, pimples

Scientific Name, Family, Habit, Accession No. Bangla name	Vernacular name	RD	RF	RA	IVI	Status**	Ethno-medicinal value
Euphorbia hirta L. Euphorbiaceae-H CUHB 059 Ghaopata	Dutta ludi (Ch)	0.51	0.27	1.36	2.15	NE	bowel complaints, helminthiasis, cough, asthma, dysentery, cuts, abdominal pain, diarrhea, chronic bronchitis, otitis, pneumonia, sore on breast, hemostatic, abscesses, inflamed glands, ulcers, edemas, phlegmons, narcotic, fever, amoebiasis
Evolvulus nummularius (L.) L. Convolvulaceae-H CUHB 060 Bhuiokra	Joinka ludi (Ch)	0.22	0.27	0.58	1.07	NE	Painful micturition, ureterolithiasis, gall stone, kidney stone
Ficus auriculata Lour. Moraceae-T CUHB 061 Kani-bot	Baro jhogna gaas (Ch)	0.15	1.07	0.09	1.31	LC	Epilepsy
Ficus benghalensis L. Moraceae-T CUHB 176 Bot	Bot gaith (Ch)	0.07	0.53	0.09	0.7	NE	Impotency, biliousness, abscesses, diarrhoea, dysentery, tonic, cooling, aphrodisiac, constipation, vulnerary, maturant, toothache, piles, diabetes, inflamed soles, rheumatic pains, lumbago, inflammations, styptic and aphrodisiac, obstinate vomiting
Ficus hispida L.f. Moraceae-T CUHB 177 Dumur	Dhumur gulu (Ch)	0.26	1.87	0.09	2.22	LC	Child fever, female disease after giving birth of child, swirling of body, purgative, emetic, cooling, astringent, baldness, epilepsy, facial paralysis, menorrhagia, lactogogue, tonic, menstrual hemorrhage, blood pressure
Ficus rumphii Blume Moraceae-T CUHB 178 Jhula bot	Gai aswathwa (Ch)	0.07	0.53	0.09	0.7	NE	Bone fracture
Ficus semicordata Buch.-Ham. ex J.E.Sm. Moraceae-T CUHB 179 Sadimadi dumur	Ududui (Mu)	0.04	0.27	0.09	0.4	LC	Aphthous complaints, leprosy, bladder complaints, visceral obstructions, tiger bite to avoid septic
Getonia floribunda Roxb. Combretaceae-S CUHB 180 Goachelata	Chui-daw (Ra)	0.26	0.27	0.68	1.22	NE	Helminthiasis, jaundice, ulcers, malaria fever, leprosy
Gmelina arborea Roxb. Verbenaceae-T CUHB 181 Gamari	Gamber (Ch)	0.07	0.53	0.09	0.7	LC	Bitter tonic, galactagogue, piles, abdominal pain, fever, leprosy, ulcer, gonorrhea, cough, blood disease, jaundice, foot mud sore, worm, liver disease, scabies, astringent, diuretic, tonic, aphrodisiac, alterative, anemia, consumption, vaginal discharges, laxative, anthelmintic, stomachic, burning sensations, septic wounds
Gnetum latifolium Blume Gnetaceae-C CUHB 182 Chorapati netum	Not known	0.04	0.27	0.09	0.4	LC	Hysteria
Grewia nervosa (Lour.) Panigrahi Tiliaceae-T CUHB 183 Asar	Tarani (Ma)	0.26	0.27	0.68	1.21	NE	Indigestion, eczema, typhoid fever, dysentery, small fox, itches, syphilitic ulceration of the mouth, jaundice

Scientific Name, Family, Habit, Accession No. Bangla name	Vernacular name	RD	RF	RA	IVI	Status**	Ethno-medicinal value
Haldina cordifolia (Roxb.) Ridsdale Rubiaceae-T CUHB 184 Keli kadam	Dakrum (Ch)	0.18	0.27	0.48	0.94	NE	Flatulence, gastric tumor, headache, vertigo, biliousness, Blood purifier, skin diseases, astringent in dysentery, sores, fever, inflammation, strangury
Helicteres isora L. Sterculiaceae-S CUHB 185 Mura	Pichrangi (Ch)	0.22	0.53	0.29	1.05	NE	Eczema, skin diseases, demulcent, astringent, bowels, flatulence, chronic dysentery, intestinal worms, dysentery, diarrhoea, biliousness, cough, asthma, diabetes, stomach affections, expectorant, antigalactagogue, griping, scabies
Holarrhena antidysenterica (Roxb. ex Fleming) Wall. ex A.DC. Apocyanaceae-T CUHB 186 Kurchi	Kuruk gach (Ch)	0.04	0.27	0.09	0.4	LC	Fever, boils, paralysis, stomach pain, itch, diarrhoea, dysentery, chronic bronchitis, jaundice
Holigarna longifolia Buch.-Ham. ex Roxb. Anacardiaceae-T CUHB 187 Jhawa	Alom-chata (Ma)	0.22	0.53	0.29	1.05	NE	Polyps in nose
Homalomena pendula (Blume) Bakh.f. Araceae-H CUHB 188 Ghondodula kochu	Shigon shag (Ch)	0.07	0.27	0.19	0.54	NE	Rheumatic pain
Hydnocarpus kurzii (King) Warb. Flacourtiaceae-T CUHB 189 Chalmugra	Balgach (Ch)	0.07	0.27	0.19	0.54	DD	Lipoma, leprosy, skin diseases, cancer, febrifuge
Hyptis brevipes Poit. Lamiaceae-H CUHB 062 Gol tokma	Chang Kasey (Ma)	0.26	0.8	0.22	1.29	NE	Lipoma
Hyptis suaveolens (L.) Poit. Lamiaceae-S CUHB 063 Tokma	Chongadana (Ch)	0.37	0.53	0.48	1.39	NE	Fever, boils, headache, stomach pain, itch, constipation, anorexia, asthma, chest pain, dehydration, general weakness, hyperacidity, hysteria, mania infantum, piles, rheumatism, snake bite, spermaturia, tuberculosis
Ichnocarpus frutescens (L.) R.Br. Apocyanaceae-C CUHB 064 Shamlota	Borduttya (Ch)	1.03	1.33	0.54	2.91	NE	Bone fracture, skin troubles, stimulant, fever, dental caries, lipoma, ostopenia, measles, stone in the bladder, strangury, wounds, eczema, cooling, demulcent, alterative, tonic, diaphoretic, diuretic, dyspepsia, diabetes, headaches, sore between fingers, scabies
Ipomoea pes-tigridis L. Convolvulaceae-C CUHB 065 Langulilata kalmi	Padiye (Ma)	0.26	0.8	0.22	1.29	NE	Cut, wound, purgative, boils, carbuncles, dog-bites
Ixora nigricans R.Br. ex Wight & Arn. Rubiaceae-S CUHB 066 Kuthi rangan	Dikranga chuillya (Ch)	0.29	0.53	0.39	1.22	NE	Diarrhoea, ear infection, paralysis, dysentery
Jacquemontia paniculata (Burm.f.) Hallier f. Convolvulaceae-C CUHB 067 Montilata	Goarung (Ma)	0.26	0.27	0.68	1.21	NE	Ointment, fever, cough

Scientific Name, Family, Habit, Accession No. Bangla name	Vernacular name	RD	RF	RA	IVI	Status**	Ethno-medicinal value
Lagerstroemia speciosa (L.) Pers. Lythraceae-T CUHB 068 Jarul	Buushi (Ma)	0.04	0.27	0.09	0.4	NE	Astringent, stimulant, febrifuge, purgative, aphthae of mouth, abdominal pain, anemia, antenata care, body pain, cold fever, diarrhoea, eczema, flatulence, general weakness, gynecological disease, worm, ill health, paralysis, stomach disorder, tetanus, tonsillitis
Lannea coromandelica (Houtt.) Merr. Anacardiaceae-T CUHB 069 Bhadi	Nyapa-bawn (Ra)	0.07	0.27	0.19	0.54	LC	Blood purifier, boils, tympanites
Leea indica (Burm. f.) Merr. Leeaceae-S CUHB 070 Bonfotka	Hoti gaith (Ch)	0.26	0.8	0.22	1.29	NE	bone fracture, abscesses, snake biting, boils, rheumatic arthritis, gastric tumor, gout, itch, paratyphoid, bubo, epilepsy
Leea macrophylla Roxb. ex Hornem. Leeaceae-S CUHB 071 Hastikarna	Ash gaas (Ch)	1.14	1.6	0.5	3.24	NE	Tonsillitis, tetanus, worm, bleeding, gastric tumor, goiter, gout, rheumatism, lipoma, astringent, alexipharmac, obstinate sores, pain
Lepidagathis hyalina Nees Acanthaceae-H CUB 072 Haya	Not known	0.26	0.27	0.68	1.21	NE	Chest pain
Lindernia antipoda (L.) Alston Scrophulariaceae-H CUHB 073 Chhoto helencha	Zai gaith (Ch)	0.4	0.27	1.07	1.75	LC	Boils

*H-herb, S-Shrub, C-Climber, T-Tree, E-Epiphyte, F-Fern, Ch-Chakma, Ma- Marma, Mu-Murang
** As per IUCN, DD = data deficient, LC = least concern, NE = not evaluated, VU = Vulnerable.

Where the greatest number of 10 species was belonged to family Euphorbiaceae that detected as most prominent plant family in the current VCF. In that order, Asteraceae and Rubiaceae was the second and third most dominant family by obtaining 9 and 8 species, respectively; sequentially Araceae, Fabaceae and Zingiberaceae were the third most each with 7 species. When it comes to the species density parameter, RD indicates that *Melocanna baccifera* had the greatest RD (9.15%) trailed by *Colocasia esculenta* (6.32%) and *Adiantum lunulatum* (5.62%). Among all the recorded medicinal plants in the VCF, most frequently found species was the *Thunbergia grandiflora* (3.2%) preceded by *Boehmeria nivea* (2.4%) and computed 2.13% for *Adiantum lunulatum, Cheilocostus speciosus, Colocasia esculenta, Curculigo orchioides and Melocanna baccifera*. On the other hand, a relative abundance (RA) study showed that *Panicum repens and Panicum maximum* were the most common with accounting 3.91% ratio in the VCF after that occurred *Melocanna baccifera* (3.04%) and *Molineria capitulata* (1.95). Therefore, Table 2 divulged that *Melocanna baccifera* was the most important medicinal plant in the present VCF attaining magnitude of 14.3 importance value index (IVI). Alongside, the vital plants in the VCF comprised *Colocasia esculenta, Adiantum lunulatum, and Curculigo orchioides*, with IVI values of 10.6, 9.63, and 8.21, respectively. Contrary, lowest IVI value of 0.4 found in *Actephila excels, Bombax ceiba, Derris mitis, Dillenia indica, Ficus semicordata, Gnetum latifolium, Holarrhena antidysenterica, Lagerstroemia speciosa, Litsea glutinosa, Micromelum hirsutum, M. minutum, Phyllanthus emblica, Psychotria adenophylla, Stephania japonica, Sterculia villosa, Stereospermum colais, Streblus asper, Swintonia floribunda, Terminalia bellirica, Vitex glabrata* and *Ziziphus oenoplia*. A sheer portion of those respondents claimed they depended only on herbal remedies to cure a range of illnesses.

Diversity of plant habits and their parts utilization

Out of all recorded plants, five diversify plant types had been noted such as herbs, shrubs, trees, climbers, and epiphytes. Of them, herbs made up the greatest percentage (34.8% with 64 species) closely behind by trees (25.96% with 48 species), shrubs (23.2% with 42 species), climbers (13.8% with 25 species), and epiphytes (1.1 with 2 species). Indigenous communities around this selected VCF treated themselves using 42 different parts of the documented plants. The most used part of which was the leaves (100 species) followed by roots (65 species), barks (46 species), fruits (23 species), stems (19 species), whole plants (18 species) and roots juice (14 species). Use of shoot, sprout, bulb, kernel, corn juice, young bud, aerial root, oil of seeds, young twig, inflorescence, root bark, unripe root, capsule, caudex, plant juice, bud, fruit juice, resin and pod had been documented only in a handful number of species. The details information of all that depicted in Table 2.

Indices of plant diversity

One way to quantify how often these species in a community are present is to use diversity indices, in which multiple elements of biodiversity (richness and evenness) are represented it statistically into a single number. One of the components of diversity indexes particularly Shanon-Weiners index (H) analysis of this VCF accounted 4.26 indicating the existence of various medicinal plants with absolutely even distribution. According to existing literature on VCF, this diversity is greater magnitude of diversification than others two community-based forest management of Renikhayong Para VCF in Bandarban and Komolchori VCF in Khagrachari: and almost identical with Beganasori and Bamer Bagechori VCF in Rangamati (Table 3). Consequently, this VCF has a Simpson's Index (D) value of 0.03, which is significantly lower than the preceding three VCFs' D (Simpson’s Index) values, implying that this VCF contains a considerably greater diversity of medicinal plants than others. With a value of 0.97 for species evenness index (E), this VCF has almost evenly distribution of all documented species in the forest likely to Beganasori and Bamer Bagechori VCF and heterogeneous to Komolchori VCF, Renikhayong Para VCF.

As compare to government-managed forests, this VCF is markedly rich in diversity than forests managed by the Bangladesh Forest Department (BFD) in terms of diversity indices that reflects on the maximum value of H, lower value of D and higher value of E than BFD forest (Table 3).

IUCN red list status

We determined the IUCN red list status of recorded plant species. Our study revealed that out of 181 plant species, vulnerable only one species (*Dipterocarpus turbinatus*), least concern 51 species, data deficit 7 species and 122 species has not been assessed yet.

There is ample proof that our predecessors were familiar with therapeutic herbs at least 60,000 years ago. As in ancient civilizations, plants have been used throughout birth to death, and people employ plants in a multitude of ways to live (Lamxay *et al*., 2011; Phumthum *et al*., 2018; Pieroni *et al*., 2017). Many of today's contemporary medications were first synthesized or extracted from plant compounds that acted as prototypes. But this traditional knowledge has been attenuated with the progression of globalization and urbanization over time (Ragupathy *et al*., 2008; Srithi *et al*., 2009). Because of that documentation and conservation of this ethnobotanical heritage is imperative as this is the finest attempt to understand their brilliance and further upkeep this for human welfare. So, the ethnomedicinal plant diversity of the Badalchori Vadi Sora VCF in

Rangamati (CHTs) was therefore identified and assessed in this study through documentation of their herbal knowledge.

During the course of our study, we identified 181 diverse medicinal plant species of variable habits under 145 genera and 65 families (Table 2), showing a similar level of diversity to prior CHT research (Faruque *et al.*, 2018, 2019; Kabir and Saha, 2014). Some global studies also analogous to current studies (Malik *et al.*, 2018; Pala *et al.*, 2019; Rana *et al.*, 2019). In this VCF, in terms of number of species the most frequent families are Asteraceae and Euphorbiaceae followed by Rubiaceae, Araceae, Zingiberaceae and Fabaceae Although this Asteraceae family supremacy may also be seen in adjacent nations such as India's Andra Pradesh and Manipur (Khumbongmayum *et al.*, 2005), as well as Myanmar's Chin state (Ong *et al.*, 2018). It is plausible that this is owing to the existence of homologous ecological, edaphic, and climatic factors. There are also a vast number of usage reports and values for such families across the world (Ferrier *et al.*, 2015; Kankara *et al.*, 2015). As part of the phytosociological assessment, one bamboo

Table 3. Comparison of diversity indices of the study with findings form other community-based Village Community Forests (VCF) and Bangladesh Forest Department (BFD) managed forests.

Diversity indices	This study	Other studies	Study sites	Managing authority
Shanon-Wiener index (H)	4.27	5.04 (Rudra *et al.*, 2021)	Beganasori and Bamer Bagechori VCF, Rangamati	Solely managed by indigenous community
		3.22 (Chowdhury *et al.*, 2018)	Komolchori VCF, Khagrachari	Solely managed by indigenous community
		4.01 (Jannat *et al.*, 2019)	Renikhayong Para VCF, Bandarban	Solely managed by indigenous community
		0.9 (Rahman *et al.*, 2016)	Kaptai National Park, Rangamati	Managed by BFD
		3.25 (Nath *et al.*, 2016)	Chunati Wildlife Sanctuary, Chattogram	Managed by BFD
Added Simpson index (D)	0.03	0.09 (Rudra *et al.*, 2021)	Beganasori and Bamer Bagechori VCF, Rangamati	Solely managed by indigenous community
		0.07(Chowdhury et al., 2018)	Komolchori VCF, Khagrachari	Solely managed by indigenous community
		0.03 (Jannat *et al.*, 2019)	Renikhayong Para VCF, Bandarban	Solely managed by indigenous community
		0.37 (Rahman *et al.*, 2016)	Kaptai National Park, Rangamati	Managed by BFD
		0.09 (Nath *et al.*, 2016)	Chunati Wildlife Sanctuary, Chattogram	Managed by BFD
Species evenness index (E)	0.97	0.99 (Rudra *et al.*, 2021)	Beganasori and Bamer Bagechori VCF, Rangamati	Solely managed by indigenous community
		0.47 (Chowdhury *et al.*, 2018)	Komolchori VCF, Khagrachari	Solely managed by indigenous community
		0.09 (Jannat *et al.*, 2019)	Renikhayong Para VCF, Bandarban	Solely managed by indigenous community
		0.62 (Rahman *et al.*, 2016)	Kaptai National Park, Rangamati	Managed by BFD
		0.72 (Nath *et al.*, 2016)	Chunati Wildlife Sanctuary, Chattogram	Managed by BFD

(*Melocanna baccifera* (Roxb.) Kurz) species exhibited its phytosociological dominance in the current investigations, with the greatest IVI value as well as a substantial proportion of RD, RA, and RF values (Table 2). Therefore, *Melocanna baccifera*, locally known as Mulibash, has an enormous value in ecosystem balance, and has socio-economic significance not only for making furniture, handicrafts, housing (Nilkanta *et al.*, 2017) but also for food (Govindan *et al*., 2016), industrial chemical components (Tripathi *et al*., 2018; Lalhruaitluanga *et al*., 2011) and medicinal importance (Kuddus *et al*., 2013).

Many of the people in the village of Badalchori Vadi ora stated their trust in the use of formulations derived from various sections of medicinal plants to cure around 379 illnesses, which they had learnt from their ancestors and testifying to the synergistic effects (one plants for multiple purposes) of plants as compared to noted species. For example, one recent study postulated that Rangamati is incredibly enriched with ethnomedicinal plants containing 144 plants under 52 families for treating 90 ailments categorized into 25 disease categories. Another study on the Chakma community of Rangamati district unearthed that they utilized 50 different species to cure 28 different illnesses (Uddin *et al.*, 2014).

Furthermore, we assessed the herbal formulation components from our investigations to determine the most often utilized plant parts as therapeutic ingredients. Our findings revealed that leaves are the most efficiently utilized plant component; unlike shoot, sprout, bulb, kernel, corn juice, young bud, aerial root, oil, oil of seeds, young twig, inflorescence, root bark, and other parts are seldom used plant parts of the Badalchori Vadi Sora peoples. (Table 2). Leaves are quite often documented to be utilized as herbal medicinal materials in Bangladesh (Rahman *et al.*, 2007) and other nations (Bradacs *et al*., 2011; Mukungu *et al*., 2016; Umair *et al*., 2017; Yemele *et al*., 2015) due to the presence of diverse bioactive compounds, ease of processing and harvesting, and sustainability (Jadid *et al.*, 2020). Plant existence is not severely harmed by plucking the leaves material within appropriate limitations, but harvesting other plant components such as stems, roots, or entire plants could be detrimental to plants' survival (Zheng and Xing, 2009). Herbs had been disclosed to be the most prevalent amongst plant habit types, whilst others had noted similar observations (Jan *et al*., 2017; Jashimuddin and Inoue, 2012; Rao *et al*., 2015; Rudra *et al*., 2021; Teklay *et al*., 2013; Ullah *et al*., 2020).

Contrary to what is often believed, phytosociological features and a calculation of the plant diversity index revealed that this community-based forest, such as Village Common Forest (VCF), is more diversified and has more uniformly distributed plant species than government-managed forest in Bangladesh as evidenced of literature. Whereas Kaptai National Park and Chunati Wildlife Sanctuary of BFD maintained forests have lower diversity indices than the present study (Nath *et al*., 2016; Rahman *et al*., 2016). More precisely, table 3 displayed that community base forest in Bangladesh had a considerably higher biodiversity status than BFD managed forests. This was possible by their community's collaborative efforts, in which they implement traditional resource management strategies to preserve forest area for long usage and to ensure a sustainable supply of their livelihood resources. Unfortunately, current generation are not interested to practice this traditional knowledge. Likewise, natural resources are depleting day by day due to various anthropogenic activities. Therefore, it is urgently necessary to document this hidden treasure before going to lost forever as well as to take necessary actions against deforestation in the study area.

This study provides comprehensive documentation of all wild medicinal plants available in community-managed natural tropical forest patches in CHTs. It revealed diversity of medicinal plants as well as their diversified uses in selected VCFs of Rangamati in CHTs. It also unveiled phytosociological attributes and diversity indices along with conservation status. Different plant

parts are used for the preparation of medicinal doses. Understanding and the uses of medicinal plants by indigenous people based on their traditional beliefs. There is a scope to investigate the medicinal properties of plants for proper identification of bioactive compounds which may be helpful in drug designing. They also be included in herbal industries with proper investigation. This study will be an extensive database for pharmaceutical and herbal industries in Bangladesh. Similar type of study can be carried out to sketch overall medicinal plant resources in all VCFs of CHTs. Biodiversity monitoring study also needed to check the diversity status and to take measures accordingly. The findings of the study will help to monitor diversity status in future. However, conservation of these medicinal plants will be challenging in near future as VCFs are depleting day by day. An *in-situ* conservation strategy involving local communities is prescribed for sustainable management of VCFs.

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