Therapeutic use of plants by local communities in and around Rema-Kalenga Wildlife Sanctuary: Implications for protected area management in Bangladesh

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Abstract

Traditional systems of medicine have become a topic of global importance recently. Increased commercialization of economically important medicinal plants has resulted in overharvesting and threatening their survival. The present study was carried out to document the indigenous uses of medicinal plants by the local communities in and around Rema-Kalenga Wildlife Sanctuary, Bangladesh. Data collection was predominantly qualitative recording the species use, identifying their relative importance (RI) and assessing the informants' consensus factor (F_{ic}) on associated knowledge. We interviewed 140 households of the local community and 5 local herbal practitioners. A total of 44 plant species were in use against 33 ailments under 10 broad disease categories. Five species were found to have high use versatility (RI>1), *Emblica officinale* L. being the most versatile. Respiratory problems scored the highest F_{ic} value (0.56) involving the use of 30% species recorded. *Terminalia bellerica* Roxb., *Sterculia villosa* Roxb., *Dillenia pentagyna* Roxb. and *Terminalia arjuna* Bedd. were being harvested commercially. Use by the community, particularly for subsistence consumption ensured sustainable harvesting, but commercial extraction of some species appeared unsustainable. Buffer zone-based commercial farming of medicinal plants with a commercial value could serve a dual purpose of assuring sustainable Alternative Income Generation (AIG) for local communities and conserving the natural resources in protected areas.

Keywords: Medicinal plants, protected area, biodiversity conservation, co-management, Bangladesh

Introduction

Until the middle of the 19th century, plants were the main therapeutic agents used by humans (Camejo-Rodrigues 2003). Much of the traditional knowledge concerning new drugs was also discovered at that time (Schultes 1962), though interest has been rekindles in the 1990s (Heinrich 2000). The practices of plant-originated traditional medicine are based on hundreds of years of belief and observations, which predate the development and spread of modern medicine (Aburjai et al. 2006). The World Health Organization (WHO 1991) estimated that about three-quarters of the world population; in particular 3.5 billion in developing countries (Johnson 2009) relied upon traditional remedies that now are being reassessed by extensive activities of research on different

plant species and their therapeutic principles (Scartezzini & Speroni 2000). Now, the potential preventive and curative properties of traditional health care systems have been recognized and are being explored (Tetali et al. 2009).

The available modern health care services are not only insufficient but also inaccessible and unaffordable for the majority of developing and least developed nations (Yineger et al. 2008). Joy et al. (1998) noted that more than 80% of the population of the developing world cannot afford the modern pharmaceutical products, even though many such countries spend 40-50% of their total wealth on drugs and health care. This situation drives them to look for other options – such as medicines, predominantly from plants, the popularity of which was unveiled by Elliot and Brimacombe (1986); they are relatively cheap, safe and generally easily available. The literature includes many examples of adopting plant-based traditional medicines by the low-income people all over the world, e.g., India (Murthy et al. 2005; Valiathan 2006; Ragupathy et al. 2007), Ethiopia (Yineger et al. 2008), Amazonia (Shanley & Luz 2003), Brazil (Almeida et al. 2006), Jordan (Hudaib et al. 2008; Al-Qura'n 2009), Turkey (Uzun et al. 2004), Cameroon (Focho et al. 2009), Bhutan (Nawang 1996), South Africa (Matsabisa et al. 2009).

Now people in developed countries are turning to traditional medication systems that involve the use of herbal drugs and remedies. Feigin (2007) reported that over 50% of the population in Europe, North America and other industrialized regions have used a traditional medicine at least once. About 1400 herbal preparations are widely used in the member states of the European Union being popular in Belgium, France, Germany and the Netherlands (Hoareau & DaSilva 1999). In the USA, the number of people using herbal medicines has increased from 2.5% in 1990 to 37% in 2000 (WWF 2009). In Japan, herbal medicinal preparations are more in demand than mainstream pharmaceutical products (Hoareau & DaSilva 1999). The developed world not only consumes herbal medicines but also is intensively involved in the trade of medicinal plant parts. According to WHO (2003a), the global market for herbal medicines currently stands at over US$60 billion annually and is growing steadily. Cunningham (1996) describes three trading sectors for medicinal plants:

- on the first level, there is national trade which can involve hundreds of species;
- the second level consists of trade across national borders but within the same continent; and
- the third level comprises formal export trade which involves the trade of only a limited number of species in significant volumes.

Bangladesh is biogeographically a transition between the Indo-Gangetic plains and the eastern Himalayas, and part of the Indo-Chinese sub-region of the Oriental realm. Due to its unique biophysical setting- the juxtaposition of a large deltoid freshwater outlet and a large sea fan- Bangladesh is endowed with a surprisingly rich diversity of plant species, estimated to about 6000 including bryophytes, pteridophytes, gymnosperms and angiosperms (IUCN 2003), about 500 of which are claimed to have medicinal or curative properties (Ghani 2003). A total of 85% of the country's population live in rural areas and almost 80% of them are dependent on medicinal plants for primary health care (Hossain 2005 cited in Chowdhury et al. 2009a). Thomsen et al. (2005) recognized the medicinal plants sector in Bangladesh as a priority domain of intervention by many stakeholders. The sector is worth US$ 14 million with local supply

comprising 70% by volume and 40% by value (Dixie et al. 2003) with an estimate of around 12,000 tonnes of dried medicinal plants collected from rural, naturally grown areas (Ahmed 2009). In the face of such significance Almeida et al. (2006) saw the recovery of the knowledge and practices associated with these plant resources as part of an important strategy linked to the conservation of biodiversity, the discovery of new medicines, and the bettering of the quality of life of poor rural communities.

The declaration of forests as protected areas is viewed as the fundamental strategy in biodiversity and watershed conservation (Kramer et al. 1997). But experience has shown that legal protection alone is not enough to ensure efficient conservation activities (Chowdhury & Koike 2010). This can be guaranteed if effective relationships between the conservation areas and local communities are maintained (Schelhas et al. 2002; Mannigel 2008). The collaborative management or co-management approach would be the appropriate strategy to build up the connection and improve the situation (Chowdhury & Koike 2010). Implementation of this strategy has demonstrated positive impacts in five protected areas in Bangladesh, in terms of forest conservation and community livelihood development (Chowdhury et al. 2009b). This approach enhanced local communities' empowerment and increased local involvement in conservation initiatives in Moheli Marine Park of Comoros Island in the West Indian Ocean (Granek & Brown 2005). A program of sustainable utilization of medicinal plants with similar approach has been initiated involving local farmers in Kakamega forest of Kenya that resulted in reduced pressure on forest herbal resources while providing alternative income to the local community (KFICP, 2010).

19 protected areas have been declared in Bangladesh and 1 more has been proposed. In Bangladesh protected areas have an intimate interspersion of human habitations, with the traditional dependency of their occupants on the forests. People living in and around the conservation areas of Bangladesh rely extensively on natural resources to meet their subsistence requirements, a considerable portion of which includes medicines (Mukul et al. 2007). Kala (2005) argued that the current trend towards increased commercialization of economically important medicinal plants has resulted in over-harvesting, leading to threats to their future productivity. The fate of tropical forests and of people dependant on them has recently attracted considerable popular interest. Yet, paradoxically, the pace of research into the indigenous plant uses and vegetation management processes that could offer alternatives to the destruction has been dwarfed by the accelerating rates of cultural and biological extinction (Philips & Gentry 1993)- a reality particularly for the developing countries like Bangladesh. Almeida et al. (2006) commented that studies on the knowledge and use of natural resources by local populations may contribute to finding economic alternatives for these populations, especially in terms of the use of medicinal plants for treating health problems. This study was undertaken in Rema-Kalenga Wildlife Sanctuary, a biodiversity rich protected area in the northeastern Bangladesh, to document medicinal plant use and its implication for effective management of the conservation area.

Study Site

Rema-Kalenga Wildlife Sanctuary (Fig. 1) is situated in Gazipur and Ranigaon unions (small administrative unit of local government) of Chunarughat upazila (sub-district) in Habigonj district. It is under the jurisdiction of Habigonj-2 Forest Range of Sylhet Forest Division located approximately 130 km east-northeast of the capital Dhaka, and 80 km south-southeast of Sylhet

city. The sanctuary, lying between 24˚06'-24˚14'N latitude and 91˚34'-91˚41'E longitude (BCAS 1997), is bounded by Tripura State of India to the south and east, Kalenga Forest Range to the north and west, and tea estates to the southwest. Bio-ecologically it falls under the Sylhet Hills zones as part of the Tarap Hill Reserve Forest, 1095 ha of which was designated as wildlife sanctuary first in 1982 and expanded further to 1995 ha in 1996 under the Bangladesh Wildlife (Preservation) Order 1973.

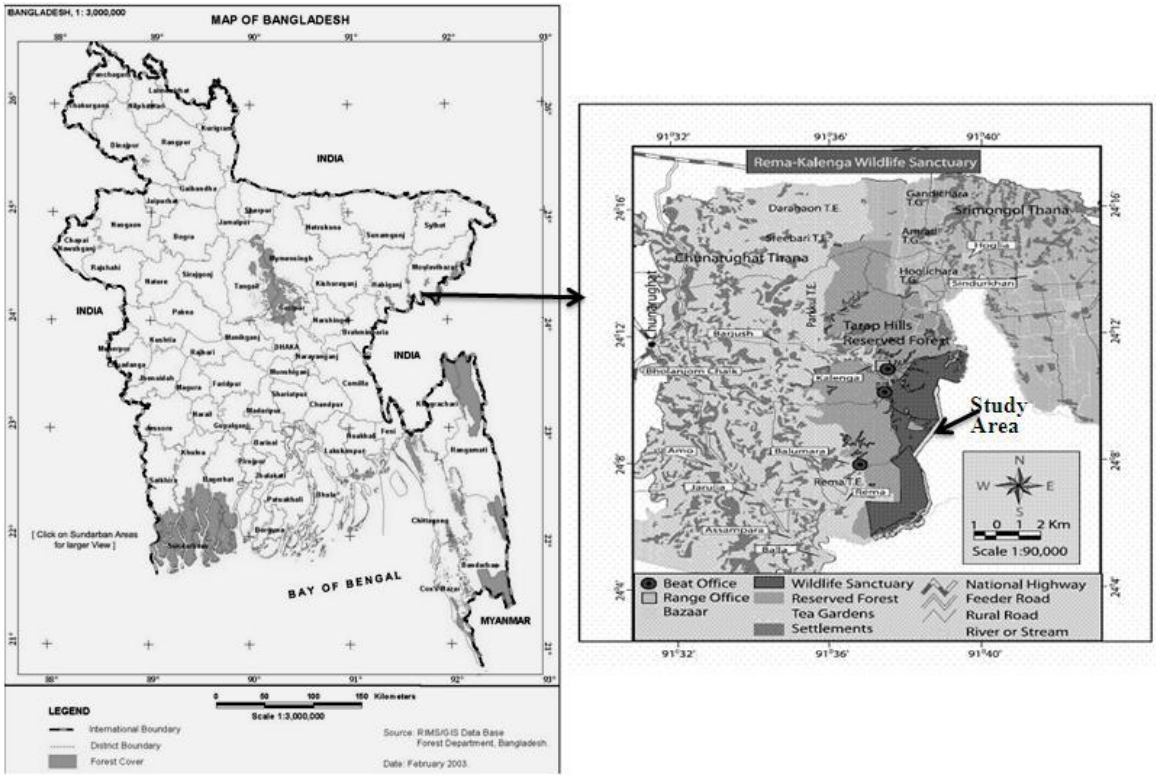

Figure 1. Map of Bangladesh and Rema-Kalenga Wildlife Sanctuary.

The sanctuary extends approximately 48 km from east to west and divided into three beats (small administrative units of Forest Department) namely Rema, Chonbari and Kalenga. It encompasses several hills of various elevations and low-lying valleys, with the highest peak at about 67 m above sea level (Rizvi 1970). Soils vary from clay loams on level ground to sandy loams on hilly ground (Ahmad 1970). The area enjoys a moist tropical climate characterized by a period of high rainfall from April to September and a five month relatively dry period from November to March (Rizvi 1970). The sanctuary remains remote and inaccessible to visitors, particularly during the monsoon, due to the lack of proper roads. This poor transportation system makes the public health care provisions in the only Upazila Health Complex and few satellite clinics difficult to reach by the rural community, thus allowing them dependent on locally available herbal treatments.

The forest of Rema-Kalenga was declared as wildlife sanctuary because of its biodiversity values and conservation needs (NACOM 2003). Its vegetation is characterized as tropical evergreen and semi-evergreen forest representing a total of 606 plant species (242 herbs, 120 shrubs, 147 trees and 97 climbers); among them 82 have been identified as medicinal plants (Uddin 2001). 76% of the forest still is in natural condition, plantation covers only 9% of the area of the forest

(Nishorgo 2009). The sanctuary is the home of a variety of wildlife; a total of 167 species were recorded of which 119 are birds, 21 mammals, 20 reptiles and 7 amphibians (Roy & Azam 1995).

The local community and their livelihoods in the sanctuary

Settlement in Tarap Hill Reserve Forest that surrounds Rema-Kalenga Wildlife Sanctuary goes back to 40-100 years (NACOM 2003). A total of 36 villages having varying stakes with the sanctuary have been identified; 1 located inside, 9 at the boundary and 26 are outside the Sanctuary. The villages inside and at the boundary have major stakes within the sanctuary as all of their households are dependent on the forest resources. Among the outside villages, 6 have medium stakes, 15 minor-medium and 5 minor stakes in the sanctuary (Nishorgo 2009). The households living in villages inside and adjacent the forest are registered with the Forest Department and recognized as Forest Villagers[1]. Eight of them are inhabited by a number of ethnic communities - *Tripura*, *Santal*, *Urang*, *Kharia*, *Kurmi*, *Goala*, *Munda* and *Bunargi* among whom the *Tripura* makes up approximately 90% of the total population (Uddin & Roy 2007).

Agriculture is the primary occupation of the people living both inside and outside the sanctuary, whereas collection of forest resources is generally a secondary livelihood activity; 12 primary stakeholders groups have been recognized, one of which is medicinal plants collectors (Nishorgo 2009). The human settlement and its pressure on the sanctuary are shown in Fig. 2. In order to reduce pressure on the sanctuary, the Forest Department has introduced several Alternative Income Generation (AIG) activities for the local communities while initiating a co-management approach under a new project - "Nishorgo Support Project (NSP)" - in 2004 (DeCosse 2006).

[1] The Forest Department (FD) allowed these communities to live in the public land inside and around the sanctuary who are traditionally dependent on forests but with no legal procedure. The FD formed the Forest User Groups (FUG) among them and gave training on various Alternative Income Generating (AIG) activities (DeCosse 2006).

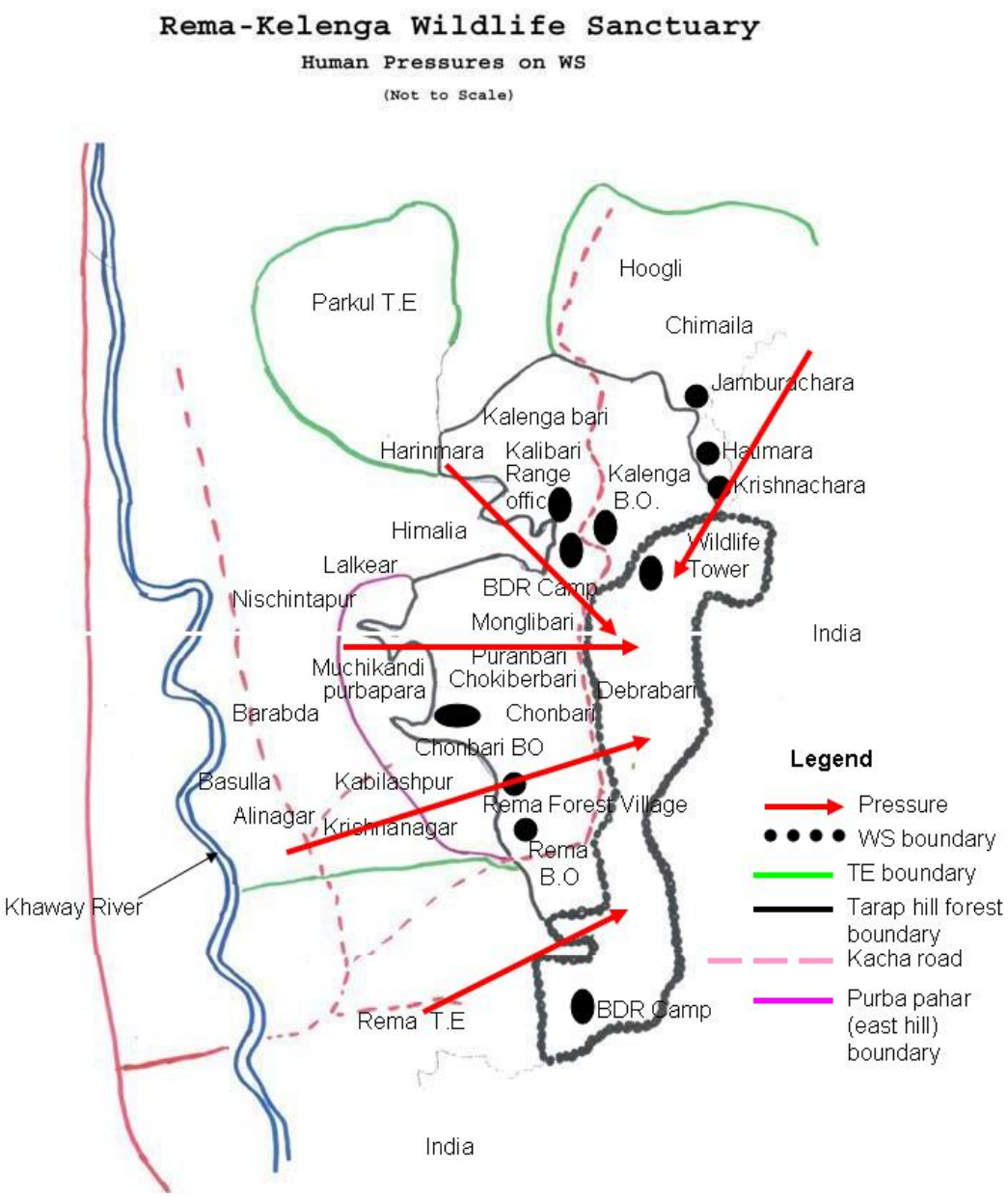

Figure 2. Human settlement and pressure in Rema-Kalenga Wildlife Sanctuary (adopted from IRG 2004)

Data Collection

The study was conducted in the months of January and February 2009. A qualitative approach with ethnobotanical interview was used to gather information. A total of 145 respondents were interviewed among whom 140 were household heads living in and around the sanctuary while the other 5 were the local herbal practitioners (locally known as *Kabiraj*) living nearby. The interviewing team was composed of 4 members headed by the first author; voluntarily assisted by the other 3 who were post graduate students of the Department of Forestry and Environmental Science in the Shahjalal University of Science and Technology, Bangladesh. 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. In case of the selection of herbal practitioners, snowball sampling (Goodman 1961) was followed that allows recruitment of further samples from the information provided by the randomly selected first sample. Although this sampling technique is often used in hidden populations which are difficult for researchers to access, we applied it in the present study to avoid the wastage of time. In addition, 3 focus group discussions were arranged in the tea stalls of local market where the rural people usually get together, gossip and interact in the evening after the day-long business. All the data has been collected from repeated conversations with the respondents to ensure the reliability of the information. This model is what anthropologists know as semi-structured, focalized interview (Pujadas et al. 2004 cited in Parada et al. 2009). The respondents were dominated by male (62%) and their age varied between 21 and 65 with an average of 35 years.

Our main purpose was to obtain the information about medicinal plants used and/or known by the respondents and document the knowledge on their application. The plants used for medicinal purposes were first recorded using local names and conventional Bangla names. Although local names of plants vary from region to region in the country, established Bangla names have been well documented by Dey (2006) together with the local names. Once local names had been obtained, the corresponding Bangla names were found by reference to Dey (2006). Voucher specimens of each medicinal plant species were also collected during the field visit and allotted collection numbers. The collected specimens were then dried and identified using standard literatures (e.g., BARC 1972-1992; Chevallier 1996; Das & Alam 2001; Dey 2006) and finally the herbarium vouchers were deposited in the SUST herbarium (Department of Forestry and Environmental Science in Shahjalal University of Science and Technology, Sylhet, Bangladesh).

Data Analysis

Apart from the species (with scientific and Bangla names, family and habit), their parts used, and ailments treated; we calculated the relative importance (RI) for each species and informants' consensus factor (F_{ic}) for each disease category.

The relative importance (RI) of the species was calculated according to the following formula (Bennett & Prance 2000), with "2", being the highest possible value, indicating the species that have the greatest number of medicinal properties:

RI = NCS + NP

- Where NCS is 'the number of ailment category treated with a given species divided by the total number of ailment categories treated with the most versatile species' and
- NP is 'the number of individual ailments attributed to a given species divided by the total number of individual ailments attributed to the most versatile species'.

The informants' consensus factor (F_{ic}) was employed to indicate how homogeneous the information is. All citations were placed into ailment categories for which the species was claimed to be used. F_{ic} value ranges form 0 to 1. A high value (close to 1) indicates that the species is used by a large proportion of the informants indicating a consistent use of the medical resources. On the other hand, a low value indicates that informants disagree on the species to be

used in treatment within a category of ailment. In other words, the F_{ic} 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 (Hudaib et al. 2008).

The F_{ic} was calculated adopting Trotter & Logan (1986) according to the following formula:

$F_{ic} = N_{ur} - N_t/N_{ur} - 1$

- Where N_{ur} is the number of use citations in each ailment category and N_t is the number of species used.

Results and Discussion

Medicinal plant resources in and around Rema-Kalenga Wildlife Sanctuary

The survey recorded 44 plant species belonging to 28 families and 36 genera, used for medicinal purposes by the local communities living in and around Rema-Kalenga Wildlife Sanctuary (Table 1). These medicinal plants include trees (34%), shrubs (32%), herbs (23%) and creepers (11%). In general, trees are the commonest medicinal plants in rural Bangladesh - as evident from several studies (e.g., Miah & Chowdhury 2003; Mukul et al. 2007; Chowdhury et al. 2009a). As rule, protected areas have a rich floral diversity, and in Rema-Kalenga Wildlife Sanctuary a total of 606 plant species were recorded during the period 1998-2000 in a floristic survey (Uddin 2001). This variety allows local communities to collect a wide range of plants and parts of plants for their informal, everyday health care. Similar situations have been reported worldwide; for instances, the use of 101, 58, 40 and 95 medicinal plants by the local inhabitants residing in and around Bale Mountains National Park of Ethiopia (Yineger et al. 2008), Mujib Nature Reserve of Jordan (Hudaib et al. 2008), Satchari National Park of Bangladesh (Mukul et al. 2007) and Velliangiri holy hills of India (Ragupathy et al. 2007), respectively.

Although 28 families with medicinal properties were recorded, only Combretaceae, Euphorbiaceae and Fabaceae were represented by three species; 9 families had two species each and the others (16) with one species. Mukul et al. (2007) also found that a number of medicinal plant species in the families Combretaceae and Euphorbiaceae were utilized by the people living around another conservation area in the same region of the study area.

Table 1 Medicinal plants used by the local community in and around Rema-Kalenga Wildlife Sanctuary, Bangladesh

Species		Growth form	Family	Parts used	Ailments	Relative Importance (RI)
Botanical Name	Local Name					
Emblica officinale L.	Amloki	Tree	Euphorbiaceae	Fruit	Jaundice, Asthma, Dysentery, Stomach trouble, Apathy to food intake,	2.00

					Fever, Weakness, Malaria	
Terminalia belerica Roxb.	Bohera	Tree	Combretaceae	Fruit	Fever, Apathy to food intake, Weakness, Malaria, Jaundice, Asthma, Gastric pain	1.88
Terminalia chebula Retz.	Hortoki	Tree	Combretaceae	Fruit	Fever, Apathy to food intake, Stomach trouble, Asthma, Weakness, Malaria	1.55
Clerodendrum viscosum Vent.	Bhat	Shrub	Verbenaceae	Leaf	Fever, Gastric pain, Cough, Dysentery	1.10
Trewia nudiflora L.	Chagol Ledi/ Motkila	Tree	Euphorbiaceae	Leaf	Chronic fever, Stomach trouble, Jaundice	1.10
Tamarindus indica (L.) Cogn.	Tentul	Tree	Fabaceae	Tender leaf, Fruit	Burning in urination, Rheumatism, Female disease	0.98
Adhatoda vasica Nees.	Basak	Shrub	Acanthaceae	Leaf	Asthma, Cough, Fever, Cold	0.90
Centella asiatica (L.) Urban.	Thankuni	Herb	Umbelliferae	Whole plant	Stomach trouble, Dysentery, Stammering, Cold	0.90
Ocimum sanctum L.	Tulshi	Shrub	Lamiaceae	Leaf	Leg swelling, Fever, Cough, Cold	0.90
Sterculia villosa Roxb.	Udal	Tree	Sterculiaceae	Tender leaf & twig	Gastric pain, Stomach trouble, Premature ejaculation in male	0.78
Allium ceipa	Piaj	Herb	Liliaceae	Tuber	Snake bite,	0.65

L.					Cold	
Allium sativum L.	Roshun	Herb	Liliaceae	Bulb	Head ache, Stomach trouble in cattle	0.65
Cajanus cajan (L.) Millsp.	Orhor	Shrub	Fabaceae	Leaf	Jaundice, Apathy to food intake	0.65
Dillenia pentagyna Roxb.	Hargeza	Tree	Dilleniaceae	Bark	Cut, Mosquito bite	0.65
Mikania scandens (L.) Willd.	Uzari/Refugee lota	Creeper	Compositae	Leaf	Cut, Jaundice	0.65
Zingiber officinale Rosc.	Ada	Herb	Zingiberaceae	Tuber	Cough, Flatulence	0.65
Terminalia arjuna Bedd.	Arjun	Tree	Combretaceae	Tender leaf, Bark	Heart disease, Apathy to food intake, Weakness	0.58
Alocasia indica Schott.	Harinpaya	Herb	Araceae	Whole plant	Gastric pain, Stomach trouble	0.45
Azadirachta indica Juss.	Neem	Tree	Meliaceae	Leaf	Scabies, Skin disease	0.45
Ferula asafoitida L.	Heez Gaach	Shrub	Apiaceae	Slender stem	Asthma, Cough	0.45
Jatropha curcas L.	Jamalgota	Shrub	Euphorbiaceae	Latex	Scabies, Skin disease	0.45
Litsea polyantha Juss.	Menda	Tree	Lauraceae	Leaf	Diarrhoea, Dysentery	0.45
Paederia foetida L.	Padra Pata	shrub	Rubiaceae	Leaf	Diarrhoea, Dysentery	0.45
Piper longum L.	Pipul Morich	Creeper (vine)	Piperaceae	Fruit	Cough, Asthma	0.45
Piper nigrum L.	Gol Morich	Creeper (vine)	Piperaceae	Seed	Cough, Asthma	0.45
Abelmoschus moschatus Medik.	Bon Derosh	Shrub	Malvaceae	Root	Leg swelling	0.33
Alocasia spp	Kochu	Herb	Araceae	Petiole	Leeche bite	0.33
Annas comosus (L.) Merr.	Anarosh	Shrub	Bromeliaceae	Tender leaf	Intestinal worm	0.33

Artocarpus lakoocha Roxb.	Dewa	Tree	Moraceae	Tender leaf	Asthma	0.33
Asparagus racemosus Willd.	Shotomuli	Creeper	Asparagaceae	Root	Low content of sperm in male	0.33
Bambusa vulgaris Schred.	Barak Bansh	Tree	Graminae	Bark dust	Cut	0.33
Cassia angustifolia Vahl.	Sonamukhi	Shrub	Fabaceae	Leaf	Gastric pain	0.33
Cassia fistula L.	Sonalu	Tree	Fabaceae	Tender leaf	Intestinal worm	0.33
Citrullus colocynthis (L.) Schred.	Makal	Creeper	Cucurbitaceae	Fruit	Birth control	0.33
Cynodon dactylon Pers.	Durba	Herb	Graminae	Tender leaf	Cut and wounds	0.33
Datura metel L.	Dhutura	Shrub	Solanaceae	Leaf	Scabies	0.33
Ficus hispida L.	Dumur	Tree	Moraceae	Inflorescence	Diabetes	0.33
Hibiscus rosa-sinensis L.	Joba	Shrub	Malvacea	Flower	Sexual weakness in male	0.33
Lawsonia inermis L.	Mendi	Shrub	Lythraceae	Leaf	Burning in urination	0.33
Leucus aspera Willd.	Dondo Kolosh	Herb	Lamiaceae	Leaf	Cough	0.33
Mangifera indica L.	Aam	Tree	Anacardiaceae	Tender leaf	Asthma	0.33
Solanum indicum L.	Bon Begun	Shrub	Solanaceae	Fruit	Flatulence	0.33
Swertia chirata Ham.	Chirota	Herb	Sapindaceae	Whole plant	Chronic fever	0.33
Zingiber zerumbet Smith.	Ekangi	Herb	Zingiberaceae	Tuber	Gastric pain	0.33

Notes on plant utilization

Both the aerial and below ground plant parts are used in health care in the study area- aerial parts 80%, below ground parts 14%, and the whole plant 6%. 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 against a single ailment. Leaves were the most widely used parts accounting

for 48% (Fig. 3) of the reported medicinal plants, followed by fruit (16%), bark (7%), roots (5%) and others (24%) that include tuber, bulb, petiole, stem, inflorescence, flower, latex, seed, twig and whole plant. The common use of leaves may be due to their availability, as has also been reported to be in use in many communities (e.g., Giday 2001; Sajem & Gosai 2006; Yineger et al. 2008; Langenberger et al. 2009). The use of leaves is compatible with sustainable harvesting (Halim et al., 2007) and provides with an incentive to protect and maintain wild populations, their habitats and the genetic diversity of medicinal plants (Schippmann et al. 2002). However, Almeida et al. (2006) and Lulekal et al. (2008) recorded that flowers and roots as the mostly used plant parts in northeastern Brazil and southeastern Ethiopia, respectively.

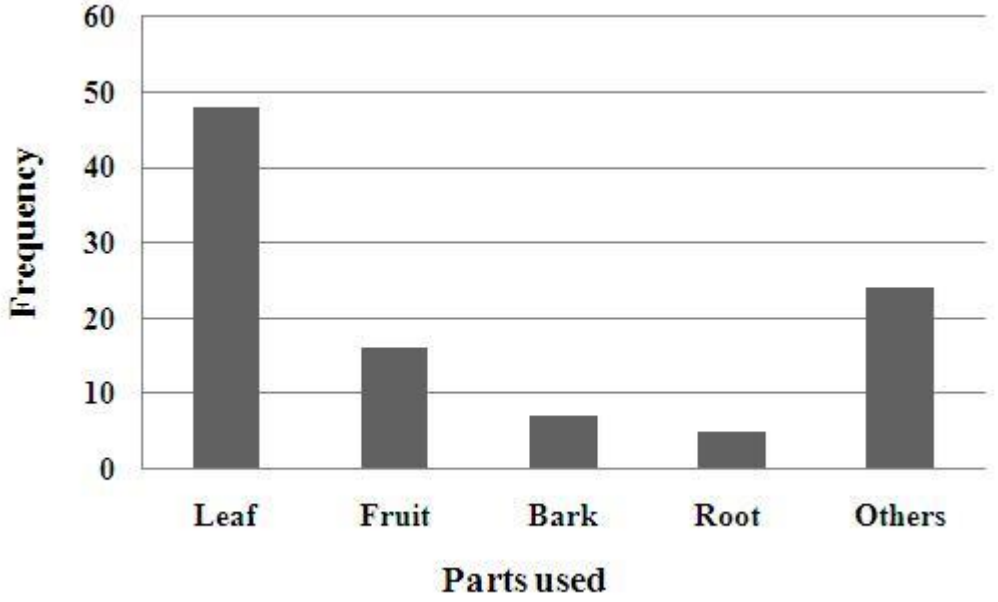

Figure 3. Use of different plant part in and around Rema-Kalenga Wildlife Sanctuary

A total of 33 different ailments were found to treat with the medicinal plants recorded. All the ailments were grouped into predefined ethnobotany categories (Heinrich 2000), with the addition of a few others, forming 10 ailment categories: dermatological, gastrointestinal, general health, faunal bites, jaundice, malaria, pain, respiratory, sexual and urinary (Table 2). Most plant parts were consumed orally after processing - such as macerating, pounding, squeezing, blending, soaking or boiling in water, rubbing or burning. Some were taken raw and some after cooking as vegetables. 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. Some unusual ingredients other than plant parts were also reported to be added to some herbal preparations. For example, paste of frog's liver is added to the mixture of extracts from the fleshy stem of *Ferula asafoitida* and leaves of *Mangifera indica* and *Artocarpus lakoocha*, which is then taken orally as a treatment for asthma. The addition of animal parts like goat's milk, chicken's egg, bird's meat; other peculiar items like cattle urine, turtle's blood and

chemicals like camphor, vermilion, calcium oxide to local herbal preparation were found in literatures (e.g., Uzun et al. 2004; Owuor & Kisangau 2005; Halim et al. 2007).

Table 2 Various ailment categories treated with medicinal plants in and around Rema-Kalenga Wildlife Sanctuary, Bangladesh

Ailment category	Biomedical term
Dermatological	Cuts & wounds
	Scabies
	Skin diseases
Gastrointestinal	Diarrhea
	Dysentery
	Flatulence
	Gastric pain
	Intestinal worm
	Stomach trouble
General health	Apathy to food intake
	Cold
	Chronic fever
	Fever
	Heart disease
	Leg swelling
	Stammering
	Weakness
Faunal bite	Leech bite
	Mosquito bite
	Snake bite

Jaundice	
Malaria	
Pain	Rheumatism
	Head ache
Respiratory	Asthma
	Cough
Sexual	Birth control
	Female disease
	Low sperm content in male
	Premature ejaculation in male
	Sexual weakness in male
Urinary	Burning in urination
	Diabetes

Relative importance of species and consensus of medicinal knowledge among informants

Five species (about 11%) of the enlisted medicinal plants were found to have high use versatility (RI >1): *Clerodendrum viscosum* (1.10), *Trewia nudiflora* (1.10), *Terminalia belerica* (1.88), *Terminalia chebula* (1.55) and *Emblica officinale* (2.00). Among these species exhibiting high relative importance values, a combination of the latter three, popularly known as *Triphala*, has been using for centuries in the folk medicine of Indian sub-continent (Miah et al. 2006), possessing the properties of removing toxins and various other undesirable accumulations from the body, improving digestion and assimilation, and acting as antioxidant (Scartezzini & Speroni 2000). As the study area, the other two species are also in use against fever in different regions: *Clerodendrum viscosum* by the *Bantar* people in Nepal (Acharya & Pokhrel 2006) and *Trewia nudiflora* by the neighboring communities of a conservation area in Bangladesh (Mukul et al. 2007).

The F_{ic} values for the disease categories (Table 3) 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 (Owuor & Kisangau 2006). Among the ten ailment categories used in our study, the respiratory problems scored the highest F_{ic} value (0.56). Thirteen species, representing 30% of the total species recorded, were in use for the treatment of this category that includes asthma and coughs. Jaundice and urinary problems were second (F_{ic} 0.55) and third (F_{ic} 0.50) with the involvement of only 5 and 3

species. The gastrointestinal category ranked fourth with an F_{ic} value of 0.43, although the highest number of species (17 species), representing nearly 40% of the total, were reported to be used in its treatment. A high consensus (0.92) for the treatment of jaundice was found among the *Malasars* community of India (Ragupathy et al. 2007) while the consensus for gastrointestinal illnesses was highest (F_{ic} 0.68) among the *Nahua* community of Mexico (Heinrich 2000). There was no consensus (F_{ic} 0) among the informants in the study area for the categories malaria and pain; perhaps this was because of the easily accessible alternative allopathic medicines available in the dispensaries and/or local shops in the study area. The respondents can buy cheaply the modern pharmaceutical medicine for preliminary pains that provides quick relief, thus reducing the use of traditional remedies. A changing trend towards allopathic medicine for the treatment of malaria, marked in the study area, was reported all over the country.

Table 3 Degree of local communities' consensus on managing various ailments in and around Rema-Kalenga Wildlife Sanctuary, Bangladesh

Ailment category	No. of plant species	Percentage of total species*	No. of use-reports	Informants' Consensus Factor (F_{ic})
Respiratory	13	29.55	28	0.56
Jaundice	5	11.36	10	0.55
Urinary	3	6.82	5	0.50
Gastrointestinal	17	38.64	29	0.43
General health	13	29.55	20	0.37
Faunal bite	3	6.82	4	0.33
Dermatological	7	15.91	9	0.25
Sexual	5	11.36	6	0.20
Malaria	3	6.82	3	0.00
Pain	2	4.55	2	0.00

* Percentage sum exceeds 100 as some species are in use against more than one category.

Collection and commercialization of medicinal plants

Almost all the medicinal plant species in the study area were found to be collected wild from the surrounding forests; being indigenous to the study area except a few like *Allium cepa*, *Allium sativum*, *Piper nigrum*, *Zingiber officinale* and *Hibiscus rosa-sinensis* which are now

widespread. The inclination of the respondents towards native species from wild source may be because of their forebears' long-timed acquaintance with the locally available species from whom the knowledge has been traditionally transmitted to the present generation. This preference for the wild harvested medicinal plants is seen in local users throughout the world. The *Shaiji* people (Halim et al. 2007) and *Garo* tribe (Anisuzzaman et al. 2007) in Bangladesh, traditional healers in Ethiopia (Yineger & Yewhalaw 2007), local people in China (Lee et al. 2008) are the few examples. Kuipers (1998) reported an estimated 70-90% of the medicinal plant material imported into Germany is harvested from the wild while more than 500 species are harvested from the wild in France. Uniyal et al. (2000) commented that medicinal properties of plant secondary metabolites produced under stress and competition are not always expressed in fast-growing monoculture; rather, higher levels of active compounds may be present in wild populations where they grow more slowly.

There is no official provision for collecting medicinal plants commercially from Rema-Kalenga Wildlife Sanctuary; all were extracted illegally. Fruits of *Terminalia bellerica*, tender twigs of *Sterculia villosa*, barks of *Dillenia pentagyna* and *Terminalia arjuna* were found to be harvested for commercial purposes while the others for subsistence use. They reported the sale of commercially harvested parts of medicinal plants to the middlemen and/or local market with a marginal price (Table 4). The local people collected the fruits of *T. bellerica* from the forest floor after their shedding at maturity; cut the tender twigs of *S. villosa* by climbing trees, sometimes twisting and breaking down the whole branch; and scrapped off the bark of *D. pentagyna* and *T. arjuna* with a sharp knife from the mature bole of standing trees. Among these four locally traded plant parts; bark of *D. pentagyna* was reported to be used for making a mosquito repellent while the others were used against human ailments. This illegal activity has led to over-harvesting leading to the risk of disappearance of the species from their natural habitat. It is evident from the comment of an elderly respondent (65 years of age) "in my childhood there was an abundance of *Hargeza* plant (*D. pentagyna*), but now-a-days I see only a few all over the forest". Uddin & Roy (2007) reported the decreasing amount of daily collection per person of parts from *Litsea glutinosa* and *T. bellerica*. The amount of bark collection from *L. glutinosa* has decreased to 2 kg and fruit from *T. bellerica* to 10.5 kg whereas the amount was 10 kg and 30 kg, respectively 5 years ago, suggesting a developing scarcity of those two plants in the sanctuary. Moreover, frequent scrapping of barks makes the trees more susceptible to injury, sometimes killing the species (Graham 2007) and collecting fruits from the forest floor may affect the regeneration potential (Uddin & Roy 2007).

Table 4 Information on selling price of commercially harvested medicinal plant parts in and around Rema-Kalenga Wildlife Sanctuary, Bangladesh

Species		Parts harvested	Selling price (Tk*/kg)
Botanical name	Local name		
Dillenia pentagyna	Hargeza	Bark	6.00
Sterculia villosa	Udal	Tender twig	10.00

Terminalia belerica	Bohera	Fruit	4.00
Terminalia arjuna	Arjun	Bark	20.00

* Bangladeshi currency unit Taka; 1US$= 68Taka (as of March 2010).

The post-collection processing of the medicinal plant parts, particularly those extracted for trade, was observed improper in the study area. The fruit of *T. bellerica* has to be dried before marketing. During the study, we saw that the fruits and bark were spread over the yard, which was buffed with cow-dung to make the surface smooth facilitating quick sun drying. As most of these plant parts are soaked in water and the liquid extract thus obtained is taken orally, contamination may make these dangerous instead of curative through the risk of introducing new infections. The World Health Organization (WHO) enunciated a set of guidelines for the collection and processing of medicinal plants. According to the guidelines, collection practices should ensure the long-term survival of wild populations and their associated habitats, and drying medicinal plant material directly on bare ground should be avoided (WHO 2003b). It suggests laying the medicinal plant parts on a tarpaulin or other appropriate cloth or sheeting, if a concrete or cement surface is used. In the case of drying in the open air, the parts should be spread out in thin layers on drying frames and stirred or turned frequently; the drying frames should be located at a sufficient height above the ground to secure adequate air circulation.

Implications for protected area management

Local communities suffer after the notification of a forest as protected area due mainly to the curtailment of the flow of forest resources for their livelihoods through strict regulation. Consequently, effective maintenance of the relationships between protected areas and the local communities has been emphasized in their management as community participation is seen as an important factor in nature conservation (Mannigel 2008). Successful conservation schemes can be achieved only if effective incentives are offered to the local communities and their roles are clearly defined of (Sawhney et al. 2007). In Rema-Kalenga Wildlife Sanctuary, many aspects of forest resource utilization are responsible for the degradation (Fig. 4). The Alternative Income Generating (AIG) activities, introduced by the NSP, with a view to reducing pressures on protected areas are: cow fattening both for beef and milk, poultry rearing, nursery production, improved stoves manufacture, nature tourism and eco-lodge, eco-guiding, service enterprises, elephant rides as tourist amusement, tribal cloths manufacture, date palm leaf baskets manufacture, social forestry in buffer zone for poles/logs, fuel wood and medicinal plants, direct payments for conservation, access to capital through NGO microfinance, CMC-led microfinance, linkages to existing Micro Finance Institutions (MFIs) and matching grants (DeCosse 2006).

Although medicinal plants cultivation was mentioned in the project plan as one of the AIGs, no such activity was reported in the study area. Rather, the local communities were given training in some activities that do not reflect their needs. The authority is not emphasizing on medicinal plant-based AIG or even recognizing it as a potential means of livelihood, which is evident from its exclusion from the list of resource collection as presented in Fig 4. But, as per the findings of the present study, the introduction of commercial cultivation of medicinal plants could be a step

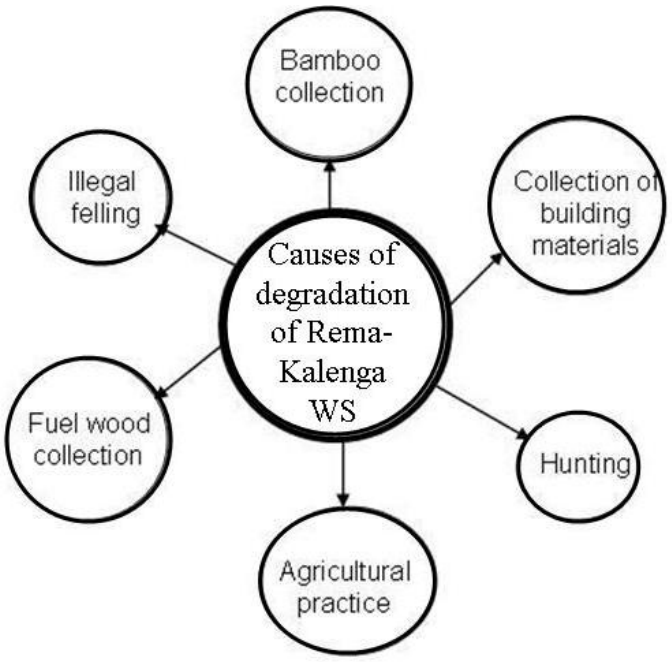

Figure 4. Resource extraction as the causes of degradation in Rema-Kalenga Wildlife Sanctuary (adopted from IRG 2004)

forward in the attempt to direct local communities towards other livelihood activities. The adjacent portion of reserve forest that is acting as informal buffer zone and the homesteads of Forest Villages could be the appropriate sites for this initiative. Because of their acquaintance with and high dependence on the plants for medicinal uses, the local people have an intimate understanding of the ecology and, in some cases, the culture of different species; this could easily provide the basis for commercial farming of medicinal plants. Small-scale agroforestry programs could be initiated for intercropping of medicinal plants with horticulture and agricultural crops to optimize the production per unit area. The driving role of the Forest Department could give it an institutionalized look. The Himalayan Forest Research Institute of Shimla has established such agroforestry models in the State of Himachal Pradesh, India (NVO News 2009). The commercial cultivation of medicinal plants involving rural communities has been successfully adopted in many other countries, e.g., India (Chatterjee 2002; Purohit and Vyas 2007), Ghana (Dennis and Owusu-Afriyie 1999), Sri Lanka (De Silva and Wettasinghe 2004), Malaysia (Lee 2004) and South Africa (Wiersum et al. 2006). Small-scale cultivation of some medicinal plants has been initiated in different places of Bangladesh also, for instances, 17 species in the homegardens of Manikganj by the rural people (Akand 2005), *Lawsonia inermis* L. in the central portion of the country by the local farmers (Chowdhury et al. 2010) and *Swertia chirata* Ham. in Madhupur Sal Forest area by the *Garo* tribe (The Independent 2010). The cultivation is being practiced inside the forests as well. The *Bhotiya* tribal community practice seasonal and altitudinal migration and stay inside the buffer zone of Nanda Devi Biosphere Reserve in the western Himalaya of India and cultivate medicinal plants (Silori & Badola 2000). Becker & Workman (2003) suggested the cultivation of some shade tolerant medicinal plants for

forest farming[2] in Florida's forests. FAO (2002) recognized the cultivation of medicinal plants as a 'conservation option' for threatened species and a means for relieving harvest pressure on wild populations.

The demand for medicinal plant material is expected to increase by Tk 300 million by value (Dixie et al. 2003), mainly concerning *Emblica officinale, Terminalia bellerica, Terminalia chebula, Asparagus racemosus, Withania somnifera* and *Andrographis paniculata* (Dixie et al. 2003), especially the *Triphala* species (myrobalan) widely used all over the country (Miah et al. 2006). Marketing of medicinal plant parts should not be a major problem since there are about 500 herbal industries of which 20 are large and consume 80% of the total raw material of the country (Ahmed 2009). Moreover, Ahmed was informed by the Hamdard Laboratories, the largest manufacturer of finished herbal products in Bangladesh, of their keenness to purchase locally produced dried plants. Thus medicinal plants farming could be a potential means of livelihoods for the forest dependent marginal people in the study area. The rural people of Natore, a northern district of Bangladesh devoid of natural forests, have adopted such farming and started earning from the medicinal plants trade (Sheuly 2008). In the focus group discussion, the community people showed their desire to cultivate medicinal plants commercially but, at the same time, expressed worries about the supply of planting material and associated technology for the initial establishment. In the quest of this, the Bangladesh Council for Scientific and Industrial Research (BCSIR) and Bangladesh Forest Research Institute (BFRI) can develop an 'elite repository' for producing quality planting (Thomsen et al. 2005). Besides, the project implementation authority can provide the community with appropriate training following the WHO guideline on 'good agricultural and collection practices (GACP) for medicinal plants'.

The other option- the controlled harvesting from wild - will require the incorporation of local people's indigenous knowledge into management matters. Kala (2005) stated that indigenous methods of utilization of natural resources, in many cases, are regarded as sustainable. In our study area, the community was found to show some degree of sustainability by harvesting leaves as mostly used plant part. Conversely, they were reported to act as the agent of reducing some species by overharvesting barks and fruits; this causes the mortality and hampers the regeneration of those species, respectively leading to population decline. Therefore, a cautious scrutiny is needed to identify the effective local knowledge so as to use it as a key factor in species conservation in the protected area.

Conclusion

Plant-based ethno-medicines occupy a vital share of the health care systems in the developing world. But medicinal plants started disappearing rapidly due to their commercialization, increased demand and unsustainable harvesting. Therefore, it is important to ensure their conservation for sustainable utilization. The present paper highlights this aspect. In correspondence with the FAO's recognition of the cultivation of medicinal plants as a 'species

[2] Forest farming is defined as the cultivation of plants under a forest canopy as opposed to wild crafting, the practice of collecting wild plants and products from a forest (Becker & Workman 2003).

conservation option', buffer zone-based commercial cultivation of widely demanded medicinal plants was suggested in the areas of Rema-Kalenga Wildlife Sanctuary, Bangladesh. It would, therefore, promote the alternative livelihoods for the local community on one hand; reduce the pressure on the protected area on the other.

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