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Review Article

Heritage Non Timber Forest Product Use and Management by Indigenous Community in Northeastern Himalayan Hotspot, Arunachal Pradesh, India

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Abstract

Arunachal Pradesh (AP), one of the northeastern Himalayan states of India, is rich in biodiversity. The threat of destruction of certain species makes it a hotspot which merits urgent attention. A literature survey revealed that more than 21 indigenous communities and 110 sub-communities are dependent on the biodiversity for basic needs like, food, medicine, shelter, energy, veterinary care and ecosystem services. It further showed that more than 950 plant species are known to these communities as heritage Non Timber Forest Product (NTFP) due to knowledge passed over generations. Out of these, there are 215 fruits, 300 vegetables, 565 medicines, 38 minor shelter materials, 21 fuel provider and 170 other products for miscellaneous uses. Several of these species have commercial potential and could be used for increasing income and employment opportunities, especially for the poor and otherwise disadvantaged people of the region. Such species require innovative attention to enhance the value of products, which in turn would improve the standard of living of the people. However, the scaling up of commercialization might problematize sustainable management of bioresources. Therefore, this could be balanced by home gardening or domesticating the commercial species, along with scientifically improved harvesting or silvicultural operations, and establishing conservation reserves in forests. A key feature of successful approach to NTFP management will be sound monitoring and evaluation of the programme taken up for marketing and conservation of vulnerable species.

Keywords: AP tribes; Conservation; Ethnoveterinary; Food; Homegardening; Marketing channels; Medicine; Value addition

Introduction

The richness of floral and faunal diversity in Northeast India is paralleled by its ethnic diversity with 220 distinct groups that include over 200 tribes speaking an almost equal number of dialects [1]. Among the seven northeastern states AP has the highest forest cover, flora and fauna, i.e. rich forest biodiversity, and ethnic communities. AP is spread over 83.743 km^2 area, 62% of which is covered with forests. The state is divided into 16 districts, inhabited by some major tribes and their subtribes, each totaling 25 to 28 tribes and 110 subtribes [2-4]. They use various plant species growing around them for medicine, food supplement and other uses in the form of various plant parts. Food supplements are generally fruits and vegetables, either eaten raw, cooked or processed. Other uses include shelter construction, energy supply, cultural need materials, and fodder for livestock.

As much as 94% of the population is dependent on the forest biodiversity and ecosystem services for subsistence in some parts of AP [1]. Biodiversity covered in this text includes only those plants which have been used by the community for various needs. The knowledge about the products and their use have been practiced and perfected over a long period of time through generations. A survey of literature available in this field, consulted for this paper, reveals a gap in research as many of the tribes have not been covered. However, the available account gives an overall picture of rich NTFP diversity and dependence of the inhabitants on natural products. Also evident is their effort towards livelihood generation through marketing and resource conservation through domestication, religiocultural efforts and other scientific methods.

Indigenous Community

Out of 26 major tribes 21 (*Adis, Akas* or *Hrussos, Apatanis, Bagnis, Hill Miris, Khambas, Khamtis, Khawas* or *Bugums, Mebmas, Mijis* or *Sajalongs* or *Nimmais* or *Dhammais, Monpas, Mishmis, Nahs, Nishis, Noctes, Sherdukpens, Singphos, Sulungs, Tagins, Tangsas and Wanchos*) are indigenous [5]. Some other names are also mentioned in the text (*Lispa, Chugppa, Bangani, Khamba, Khowa, Mishing Miri, Yobin /Lisu, Zakhring /Meyor, Idu mishmi, Galo, Koro, Sartang, Tai Khamti, Khamba, Adi -gallong, Adi-Miniyong, Adi-Padam, Dafla, Deori, Galong, Nishang*) which may be the important sub-tribes [6]. This is further revealed in a study where *Adi* tribe has been mentioned to have sub-tribes like *Padam, Minyong, Pasi, Bori, Bokar, Karko, Milang, Ramo, Pangi, Shimong, Ashing, Tangam* etc. [7]. One can find some confusing names as there is spelling variation in the text, for example, *Nishi=Nyishi=Nissi, Monpa=Mongpa, Sinpho=Singpho* etc. Each of the tribes and sub-tribes has a unique tradition, culture and

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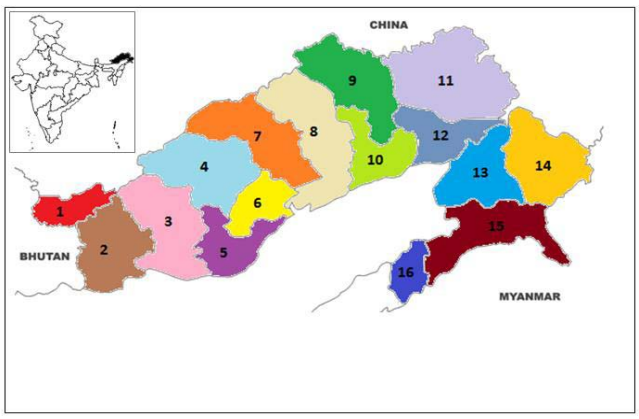

Figure 1: Arunachal Pradesh (shaded in the map of India, top left) shown above with districts as follows: 1 Tawang, 2 West Kameng, 3 East Kameng, 4 Kurung Kumey, 5 Papum Pare, 6 Lower Subansiri, 7 Upper Subansiri, 8 West Siang, 9 Upper Siang, 10 East Siang, 11 Upper Dibang Valley, 12 Lower Dibang Valley, 13 Lohit, 14 Anjaw, 15 Changlang and 16 Tirap.

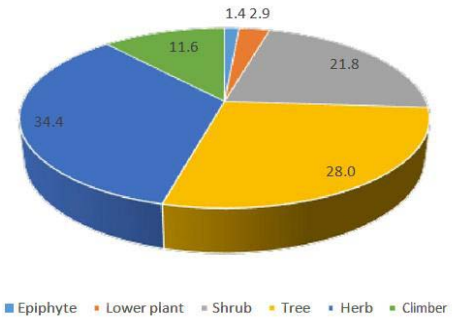

Figure 2: Contribution of various forms of recorded plants to NTFPs in the state indicating the highest contribution of trees while of the lowest is the epiphytes.

lifestyle dependent mostly on biodiversity, mainly forest and wildlife, of the state [2]. However, based on the priority and preference of research, only 18 tribes/subtribes have been covered in different study areas (Table 1, Figure 1).

Heritage NTFPs

Ninety four percent of AP is hilly with the elevation ranging from 100m to 7500m. It receives 1500mm to 3750mm annual rainfall with 80% relative humidity and temperature 0 to 31°C. The climatic conditions are tropical, subtropical, temperate and alpine providing a large range of flora and fauna which has led to this being designated as one of the biodiversity hotspots of the country [3,6]. The rich flora and fauna have provided an initial advantage to the inhabitants for observing the biodiversity for developing their own traditional knowledge [8] which have been handed down the generations through folklore and powerful oral literature [2]. Extensive search of literature showed that varied use of more than 950 plant species is well known to the tribes of AP (Table 2a and 2b). Out of these, 215 species are consumed as fruits, 300 species as vegetables, 565 species as medicine, 38 species as minor shelter material, 21 species as fuel provider and 170 species for miscellaneous uses. There is an absence of written documentation of traditional healing knowledge and its transmission to the future generation takes place only through oral communication in AP [9] as well as in other parts of the world [10]. Further, the Indigenous and tribal communities around the world are strong believers of nature and accordingly use, worship and conserve natural resources, including biodiversity [11]. The long association of the tribes with nature, as a result of a lifestyle that requires co-existence with nature, has made them dependent on it for all their routine requirements. Eventually a time came when the output from their traditional agricultural practices were not adequate to feed them for the whole year, and there were crop failures as well making the situation more dire. To cope with this, they had to depend on wild edibles for the lean period [12] mainly to take care of nutrient requirement. Additionally, health care was also managed from the natural resources being used as medicines. Such edibles came from different parts of the plant like, bark, culm, flowers and inflorescence, fruiting body, fruits and seeds, leaves, pith, pseudo -stem, resin, rhizome, roots, shoots, stem, thorn, trunk, tuber and whole plant. Most of the studies related to the contribution of different plant parts are confined to medicinal and edible uses without much emphasis on other consumption of NTFPs [8,9,12-16, etc.]. A majority of the products are of foliage and fruit origin followed by seed, rhizome and others [9,17-22]. However, another study pointed out that the percentage of fruit was greater than leafy product [23,24], bark [15], and roots and rhizomes [16].

All the forms of trees like herbs, shrubs, trees including bamboos and palm, climbers including canes, epiphytes including orchids and lower plants including mushroom have been identified for their utility and products of large range like supplementary food, medicine, shelter construction materials etc. NTFP diversity (Figure 2) used by the tribes of AP are composed of herbs (34.4%), tree (28%), shrub (21.8%), climber (11.6%), lower plants (2.9%) and epiphyte (1.4%). This order of contribution in three previous studies is found to be the same but percentages of contribution are varying, for example, herbs (46%), trees (27%), Shrub (19%), Climber (15%) etc. [19]; herb (52%), tree (20%), shrub (18%), climber (4%) etc. [21]; herb (38%), tree (27%), shrub (24%), climber (11%) etc. [9]. The same or different products of a species are used by one or more tribes (up to 16). However, there is a varied demand among tribes in terms of number of plants used. Geographical availability as well as knowledge about the utility of plants or NTFP among the tribes causes a variation in demand. Based on this they could be categorized as High, Moderate and Limited Demand Plants with value given to plants which are being used by many tribes. For example, High demand plants - NTFP used by 10 or more tribes, Moderate demand plants - NTFP used by 5-9 tribes and Limited demand plants - NTFP used by <5 tribes. (Tables 3,4 and 5) present the account of such plants having medicinal, fruits and vegetable use, respectively.

Cross Cultural Use

More than 5 tribes are using *Acorus calamus, Centella asiatica, Gynocardia odorata, Paedaria foetida, Zanthoxylum armatum* and *Zingiber officinale* (Table 3). Even more popular are *Ageratum conizoides, Clerodendron colebrookianum, Houttuynia cordata* and *Spilanthes paniculata* being used by ten or more tribes [2,8-10,19-23,25-39 etc.]. Most popular plant *Ageratum conizoides* is used by *Adi, Aka, Apatani, Galo, Idu, Lisu, Monpa, Memba, Padam, Singpho,*

Tagin, and *Tangsa*. Other very popular plants among the Arunachal tribes are *Clerodendron colebrookianum (Aka, Adi, Apatani, Idu, Hill Miri, Memba, Monpa, Nyishi* and *Miji), Houttuynia cordata (Adi, Apatani, Bugun, Galo, Lisu, Mishing, Monpa, Nyishi Singpho* and *Padam)* and *Spilanthes paniculata (Adi, Aka, Apatani, Idu, Khampati, Memba, Nyishi, Padam* and *Tangsa)*. The use of some medicinal plants for the same purpose by more than one community might indicate their pharmacological effectiveness. A survey on the pharmacological properties of medicinal plants revealed the presence of bioactive compounds in many species which could be attributed to pharmacological effectiveness of plants used by the tribal community for treating various ailments [21].

However, the same plant could be used for the treatment of different ailments by different tribes [26]. For example, *Centella asiatica* was used by 9 groups (*Bodo Kachari, Jaintia, Apatani, Chutia, Mishing, Bodo Rajbongshi* and *Rangias,* and *Lushai*) distantly located within and outside the state (Assam, Meghalaya, Manipur, and AP) for different disorders like, gastric trouble, eye injury, cholera, dysentery, leprosy, tuberculosis, asthma, deworming etc. Although there are several similar examples available within the tribes of AP, just one is narrated here for the sake of brevity. *Clerodendron colebrookianum* is being used by *Apatani, Nyishi, Idu, Aka, Monpa, Adi, Hill Miri, Memba, Nyshi,* and *Miji* for reducing blood pressure, as anthelmintic, in the treatment of diarrhea, cough and cold, liver disorders, cure of headache etc. Such a wide range of use indicates the presence of different elements responsible for curing different problems. Some experimental evidences suggest that leaves of *Clerodendron colebrookianum* possess antihypertensive agent, significant anthelminthic properties [40], hepatoprotective efficiency [41], antiperoxidative and lipid lowering activity to treat hypercholesterolemia [42] etc. Additionally, phytochemical screening of *Clerodendron colebrokianum* showed the presence of different types of compound like alkaloids, carbohydrate, phenols and flavonoids, and saponin, which might be responsible for antioxidant and antimicrobial activity [43]. Similar to this almost all the medicinal plants have definite ailment protective potentiality, and there is a valid scientific basis for consuming it for better health in NE region of India. Since it is beyond the scope of text to give details of >565 medicinal plants used by the AP communities, only High and Moderate Demand Plants (Table 3) are presented with their properties, uses and important phytochemicals (Table 6).

Use Options

The local inhabitants of the state have their own customs, traditions and medicinal system. They mainly depend on forests and forest products for their daily living [22]. However, usage and application differ from locality to locality and community to community [44]. Their dependence on forests is primarily for supplentary food requirements and medical care from the NTFPs in various form. NTFPs include medicinal plants, wild edible plants, fuel wood, fodder and forage, house building and thatching materials, spices, coloring materials, fibers, rubber, beverages and narcotics, latex, tannin, resin etc. [37]. Some of these forest products are collected throughout the year while some others are collected seasonally for one to six months.

Food supplement and famine food

Other than traditional food items, like rice, wheat, millets, etc. the indigenous community have a treasure of knowledge about potential food plants in the forests. These are different components of herbs, shrubs and trees like, leaves, stems, bark, roots, fruits of wild plants and a number of animals and insects gathered as food items [7]. Green vegetables, including fruits, are part of traditional food habits, mainly used as an essential complement to the daily diet, providing vitamins, minerals, fibres, specific aminoacids and other active metabolites [45]. These substances eventually scale up the dietary balance and simultaneously alleviate hunger and malnutrition problems [46]. To achieve this, besides growing a few crops, the indigenous community frequently collects diverse wild edible plants and other plants from natural habitats to meet their subsistence needs [47]. There is a long list of food plants to meet the requirement (Table 2a, 2b), however, there are some specific plant products which are consumed as food during a period of crisis. During famines people throughout the world depend on unconventional plant items to satiate their hunger and meet their nutritional needs. The unconventional food plants are also medicinal plants and thus can play a role in satiating hunger, meeting nutritional needs, and serving therapeutic purposes [48]. Rhizome of *Angiopteris evecta* is used as famine food by Adi [32] and stem of *Wallichia densiflora* is used to extract flour by *Galo/Nishi/ Tagin* [12]. *Bombax ceiba* and *Ficus hispida* [25,48] and *Colocacia esculenta* and *Manihot esculenta* [20] are other famine food.

Health care

The traditional communities of the Northeast have built a precious knowledge base about the use of rich bioresources of the region over hundreds of years [6]. They have a strong heritage of herbal remedies which is an integral part of indigenous culture [26]. Each tribal group has a particular indigenous medical culture or ethno - medicine knowledge and practices for curing various ailments [22]. Some notable progress has been made in the field of ethnomedicinal research on the tribes of AP during last two decades (Table 1), still many tribes are yet to be explored [7]. More than 565 plant species have been recorded out of which the ten most popular medicinal plants, among various tribes, are *Acorus calamus, Ageratum conizoides, Centella asiatica, Clerodendron colebrookianum, Gynocardia odorata, Houttuynia cordata, Paedaria foetida, Spilanthes paniculata, Zanthoxylum armatum and Zingiber officinale*. These tribes are *Adi, Aka, Apatani, Galo, Hill Miri, Idu, Khampati, Lisu, Memba, Miji, Monpa, Nyishi, Padam, Singpho, Tagin, Tangsa and Wancho*.

Past studies have primarily focused on listing vernacular names of plants and their traditional medicinal uses with some information on botanical aspects. However, there is only one record [27] on traditional ethno pharmacological practices, documenting medicine preparation by mixing multiple plant products of different species, involving 24 medicines and their procedures of preparation by the *Monpa* tribe. This document describes the name of medicinal plants used in combination and the mode of preparation of different types of medicines (mixture, pills, decoction, paste, powder, syrup etc.) by traditional healers. It also details the proportion of used plant parts expressed in bray (1 bray or bowl contains approximately 900 g of grain).

Ethnoveterinary products

Ethnoveterinary is the traditional knowledge regarding use of

plants and plant products for treatment of animals [49]. Elsewhere in the country and abroad, ethnoveterinary research has lead to important results [50] and important plants like *Bambusa vulgaris*, *Plantago major, Citrus limoni, Carica papaya* etc. have proved to be good for animal healthcare. The indigenous people of AP have developed a veterinary medicine system to treat certain ailments of their livestock. *Aconitum fletcherianum, Acorus calamus* [20], *Elsholtzia blanda* [39] are some examples of such plants used by Arunachal tribes. *Monpa* ethnic group use the leaves of *Cannabis sativa* to cure dysentery and diarrhea in cattle and goats [35]. The stem of wild *Musa paradisiaca* is given to cattle particularly during pregnancy to enhance the yield of milk. A paste obtained from the whole plant *of Plantago major* and *Ageratum conyzoides* is commonly tied to the affected portions of cattle and goat for relief from severe pain and inflammations. Ripe pods of *Gymnocladus assamicus* are soaked in water and used as disinfectant for cleaning wounds and parasites like, leeches and lice on the skin of livestock. Such limited records of ethnoveterinary use of plants appear to be a case of under-reporting as there is no literature from AP in major journals. A list of twenty plant resources for ethnoveterinary use has been published from a neighbouring state [51]. Most of these plants are found in abundance in AP and are used as NTFP for various other purposes. Some such common plants are *Bauhinia verigata, Embelia ribes, Rubia cordifolia, Rubus ellipticus, Schima wallichii* etc. *Adi, Apatani, Bugun, Galo, Miji, Monpa, Nyishi* and *Tagin* are known to use various plants as fodder for their cattle and pigs [19,20,23,36,39]. Such plants are *Begonia obversa, Buddleja asiatica, Colocasia affinis, Cyathea gigantea, Cyathea spinulosa, Ficus hirta, Galinsoga parviflora, Gonostegia hirta, Inula cappa, Musa sapientum, Musa velutina, Persicaria bartata, Phrynium pubinerve, Plantago erosa, Pouzolzia sanguine, Rumex nepalensis, Spondias axillaries, Taxus wallichiana, Thysanolaena maxima* and *Wallichia disticha*.

Shelter and energy plants

The secondary requirement of shelter construction is met with nontimber species like, bamboos, canes and other fiber yielding species growing in nearby areas. Several varieties of bamboo (*Arundinaria maling, Arundinaria racemosa, Bambusa pallida, Bambusa spinosa, Bambusa tulda, Chimonobambusa callosa, Chimonobambusa hookeriana, Dendrocalamus hamiltonii, Neomicrocalamus manii, Phyllostachys bambusoides, Phyllostachys manii, Schizostachyum helferie and Schizostachyum pergracile*) and cane (*Calamus acanthospathus, Calamus erectus, Calamus flagellum, Calamus leptospadix, Calamus tenuis, Chimonocalamus griffithianus* and *Plectocomia himalayana*) are known to be used by *Aka, Apatani, Hill Miri, Lisu, Miji, Monpa and Nyishi* [2,19,20,23,31,37]. Crooked bamboo from conjusted clumps and small wood from the branches and saw waste of different tree species (*Alnus nepalensis, Castanopsis hystrix, Castanopsis indica, Castanopsis tribuloides, Cinnamomum bejolghota, Cinnamomum caudatum, Corylopsis himalayana, Exbucklandia populnea, Ficus fistulosa, Gnaphalium affine, Magnolia champaca, Magnolia oblonga, Pinus roxburghii, Pinus wallichiana, Quercus griffithii, Quercus lamellosa, Quercus lanata, Sageretia filiformis* and *Schima wallichii*) are used as fuel wood by *Aka, Adi, Apatani, Hill Miri, Monpa, Sherdukpen, Tagin* etc. [2,19,20,23,31,39].

Plants of cultural value

There is a close relationship between the forest and religious practices of ethnic communities. They believe that natural objects like mountains, hills, rivers, ponds, the sun, the moon, the earth, etc. are possessed by spirits. Donyi-Polo (Sun and Moon) is the main religion followed by the community of the area. They are god -fearing and believe that every event in their life is guided and controlled by different kinds of spirits. In every religious ceremony they utilize a creeper (*Adi*) to protect themselves from the attack of evil spirits [7]. Despite intrusion of modern culture and technologies, *Apatani* are still practicing their rituals, customs, cultures, etc. They have been using and conserving selected plant species, which are associated with traditional rituals and festivals. The plants that are used for festivals like *Myoko, Murung, Dree* etc. are also used for other rituals and ceremonies where altar (*Agyang*) making and chanting are performed. More specifically, the species of bamboo, (*Phyllostachys bambusoides*), cane (*Calamus acanthospathus*) and *Castanopsis* spp. are the main plants used for making the altar for any rituals or chanting in marriage, birth or death ceremonies. Species of bamboo and cane are also used during death rituals for making the burial place [11].

Poisonous plants

Fishing and hunting are two of the important economic activities for many tribes of AP. The protein content in their diet depends on wild fishing in the neighbouring rivers and animal hunting. As an exception *Apatani* practice pisciculture in their paddy fields. However, other tribes use fish poison to kill the free moving fish and then sieve them from running water. This fish poison is extracted from different parts of specific plants. Different tribes like, *Aka, Nyishi, Hill Miri, Memba, Monpa, Adi, Apatani* etc. follow this practice [2,3,19-21,23,31,35,36,39]. Plants yielding fish poison are *Acacia pinnata, Aesculus assamica, Aesculus pavia, Ageratum conizoides, Anamirta cocculus, Canthium dicoccum, Castanopsis indica, Clematis buchaniana, Croton tiglium, Cyclosorus extensus, Dioscorea deltoides, Gynocardia odorata, Persicaria hydropiper, Polygonum barbatum, Polygonum hydropiper, Spilanthes olerecea, Taxus wallichiana and Tephrosia candida*. Animal poison producing plants are *Aconitum ferox, Aconitum heterophylla, Ariseama consanguineum, Clematis buchaniana, Forrestia mollissima* and *Trichosanthes bracteata*.

Other uses

Other than the major uses, discussed above, there are a few more significant NTFPs, keeping culture, customs and traditions in view. The *Apatani* make salt using plants (*Angiopteris evecta, Cyanthillium cinereum, Dicranopteris linearis, Phragmites karka, Clerodendron colebrokianum, Cirsium interopositum*) as raw material [19,31,52]. Several plant products are used to flavor traditional food items [19,20,23-25,36] by *Adi (Amomum aromaticum, Amomum dealbatum, Cinnamomum zeylanicum, Eryngium foetidum), Apatani (Perilla frustescens), Galo/Nyishi/Tagin (Allium cepa, Allium hookeri, Amomum aromaticum, Amomum subulatam, Cinnamomum tamala, Cinnamomum zeylanicum, Coriandrum sativum, Curcuma longa, Perilla frustescens, Piper nigrum, Zingiber officinale), Memba (Cinnamomum zeylanicum, Elettaria cardamomum), Miji (Litsea citrata, Piper sylvaticum, Rhynchoglossum lazulinum)* and *Monpa (Amomum maximum, Cinnamomum caudatum, Cinnamomum tamala, Elsholtzia flava, Illicium griffithii, Litsea citrata)*. There are some more products used as masticatory, rope making, incense material and natural dye (*Begonia roxburghii, Daphne papyracea,*

Engelhardia spicata, Everniastrum nepalense, Eurya accuminata, Juglans regia, Mahonia napaulensis, Miliusa globosa, Parmotrema tinctorum, Pinus wallichiana, Punica granatum, Rubia cordifolia, Rubia manjith, Rubia sikkimensis, Woodfordia fruticosa).

NTFP Management

Commercial plants

The demand for medicinal plants is increasing everywhere, as people are more fascinated by herbal medicine. It is the same case with edible products like fruits and vegetables, due to rising indigenous populations and increasing fascination towards natural products. Indigenous fruits and vegetables represent inexpensive and high quality nutrition sources for the poorer segment of the population. The commercialization of these traditional vegetables and fruits in the domestic markets would result in raising the standard of living, especially in the rural community [53,54]. Therefore, to meet the rising demand of NTFPs, the scientific large -scale cultivation of commercially important medicinal plants and edible products may open up avenues for rural people in terms of greater income. Thus, the systematic and organized cultivation of wild plants and the creation of efficient processing and marketing channels may boost the economic development of this tribal state [34]. Based on local preferences and high commercial feasibility, 18 species (*Acorus calamus, Allium hookeri, Allium tuberosum, Cerasus cerasoides, Choerospondias axillaris, Clerodendrum colebrookianum, Clerodendrum glandulosum, Litsea cubeba, Magnolia champaca, Myrica esculenta, Phyllostachys manii, Piper pedicellatum, Pyrus pashia, Rubia manjth, Chimonocalamus griffithianus, Solanum kurzi, Solanum myriacanthum and Zanthoxyllum armatum*) are identified for *Apatani* tribes in Ziro valley [19]. Twenty-nine commercially important species are further identified on the basis of price and production [31] in which some are common to the previous study. On these lines commercially important species could be identified for different localities (at least most commonly used plants, Table 3,4 & 5) and their cultivation and marketing strategy could also be formulated.

Value addition

Value addition to products is well known to enhance the financial outturn. Currently most of the NTFPs are harvested and used fresh by the community, especially food supplements and herbal medicines. Primarily they are consumed at the local level and the surplus is sold in the local market without value addition except in some cases of semi processing. Other than green consumption, dried NTFPs are also stored for some time and consumed as and when needed. A few NTFPs are powdered and stored in wooden/bamboo vessels. Primay level of grading is practiced only by cleaning to remove unwanted dirt from the lot collected in bulk [31]. Only one product *Tapyo*, a local salt, is manufactured by intense processing by *Apatani*. Most commonly, the sale of fruits or vegetables is undertaken which provides minimum return due to fairly low shelf-life, low popularity and market costs. Some value addition in the form of pickle, chutney, jam, jelly, etc. may increase fruit shelf-life and economic profit to local communities. This reflects a clear need to diversify the product base and to ensure that wild edible plants fetch higher prices [55]. Product positioning strategy in the market could also be used as added value. Any indigenous product has some attributes (natural, native, traditional, sustainable, herbal, heritage etc.) which are highly valued by the modern consumer since it connects them with something not available easily and everywhere [31]. As suggested by Jha [31] in research on *Apatani* products, a brand of any indigenous product could be created based on these valuable attributes with an aim to enhance the commercial value of the products. On the line of "Arkiset Aromit" of Finland "Indigenous Flavours", "Heritage Flavours" "Aboriginal Taste", "Ethnic Taste", "Wild Fresh" etc. could be created by promoting wild value and health benefit.

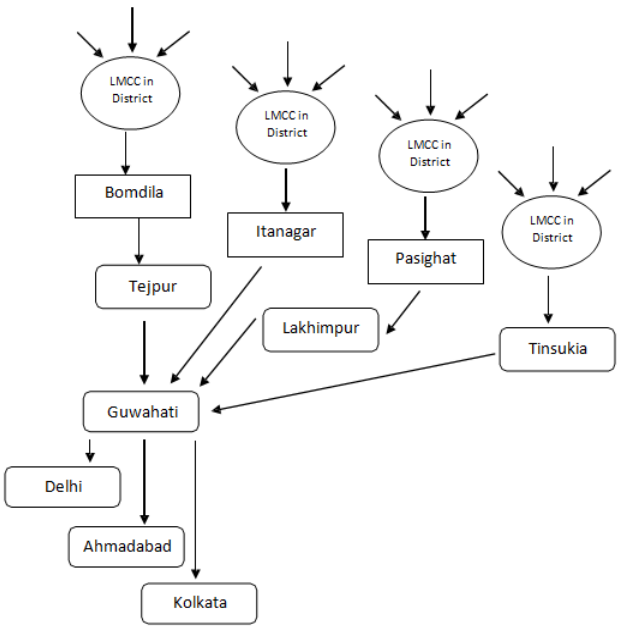

Figure 3: Marketing channels of NTFPs produced in Arunachal Pradesh. Local markets and collection centers, (LMCC, ovals), are the primary source to feed first level regional markets (rectangles like, Bomdila, Itanagar and Pasighat; all in Arunachal Pradesh), which in turn are the feeders of interstate markets (rectangle with blunt corners like, Tejpur, Lakhimpur and Tinsukia *via* Guwahati; all in Assam). Arrows are the levels of transfer agents from source to the consumer end.

Marketing channels

The surplus production of selected NTFPs by tribal communities in AP are sold in local market and many a times to agents for markets outside the locality [56]. Very few workers [16,19,25,31,54,55,57] have given an account of NTFPs being marketed with the aim of enhancing the earning of the community. Most commonly marketed NTFPs (Table 7) are for medicinal use and supplementary food. Local markets are generally village level markets within the districts, and external markets are outside the districts at regional level or outside the state at interstate level. The market channels are given in Figure 3 as modified from Jha [31]. Apart from village or district level markets, there are three major regional centers in AP, Bomdila in the west, Itanagar in the center and Pasighat in the east. These centers take care of local consumers and work as forwarding centers to interstate markets. There are two more centers in the neighbouring state of Assam, Tejpur and Lakhimpur, which are fed by local collections only. Earlier these two centers were a stronger market when transport and communication was less developed in this area. Guahati in Assam is the most important and major external market (fed by Bomdila, Tejpur, Itanagar, Lakhimpur and Pasighat)

Figure 4: Plant products consumed raw or cooked as food supplement. First row: *Houttyunia cordata* Thunb., *Diplazium esculentum* (Retz) Sw; Second row: *Oenanthe javanica* (Blume) DC, *Allium hookeri* Thwaites; Third row: Apatani herbal salt making plants *Pinging, Babu raru*; Fourth row: *Piper pedicillatum* C. DC, *Clerodendron colebrokianum* Walp.

Figure 5: Plant products consumed raw or processed as medicine. First row: *Centella asiatica* (L.) Urban, *Spilanthes paniculata* Wall ex DC; Second row: *Panax pseudoginseng* Wall., *Paris polyphyla* Smith; Third row: *Solanum torvum* Swartz, *Solanum kurzii* Brace ex Prain; Fourth row: Wild strawberry, *Cardamine hirsuta* Linn.

which sends the consignment to Delhi, Kolkata and Ahmedabad for end consumption. However, current price spread condition in these markets is not sufficient to create good income for the producers.

This could be improved by strengthening the information passage system and changing the informal nature of the market to formal one, if possible [56]. Some of the medicinal and food plants sold in these markets are presented in (Figures 4 and 5).

Vulnerable plants

Consumption, harvesting and regeneration of any NTFP mitigates its vulnerability. They could be put into the category of "very low vulnerability, low vulnerability, moderate vulnerability, high vulnerability and very high vulnerability" based on availability status and availability trend [56]. This classification is based on qualitative assessment which could be further strengthened by using some quantitative parameters like actual production/extraction, regeneration period, harvesting method etc. This instrument can be used in making "commercialization plan and conservation strategy" of the NTFPs. Consequently, vulnerable species should be conserved and non vulnerable species could be commercialized. However, a balance needs to be struck between commercialization and conservation by adopting a comprehensive policy based on scientific and traditional knowledge for harvesting and regeneration of NTFPs keeping in mind a minimal impact on the heritage of the tribals. Other than the list of vulnerable *Apatani* plants [56], currently a list of high value medicinal plants in the higher altitude forests of AP, indicating restricted distribution with high degree of threat is available [16]. This warrants immediate attention for their conservation. Such plants are *Campylandra aurantiaca, Coptis teeta, Curculigo orchioides, Gymnocladus assamicus, Picrorhiza kurroa, Panax sikkimensis, Panax pseudoginseng, Paris polyphylla, Saussurea gossypiphora, Swertia chirayita, Swertia hookeri, Taxus wallichiana, Aconitum ferox* etc. Out of the various threats observed, improper harvesting, habitat loss and trade are found to be most destructive to the population. Intensive efforts from both *in situ* and *ex situ* conservation practices are necessary for sustainable management and conservation of these species.

Conservation threats and efforts

Realizing the ecological importance and economic utility of medicinal plant resources, there is growing concern throughout the world about the need for their conservation [28]. However, a majority of high value medicinal species are faced with a number of conservation threats [16]. Habitat loss is one of the major common threats to all the species, effected by landslides, jhum cultivation,

occasional forest fire, human settlement and various other developmental activities like road construction and human habitat expansion. Grazing and trampling by free ranging animals are also the causes of destruction of herbaceous plants [58-60]. Other perceived threats are high volume and unscientific collection, excessive lopping of branches of tree species, maximum collection per unit labour to gain maximum profits [20]. Jha [56] observed that overharvesting is generally due to commercial trading of several species which is detrimental to regeneration. Technological inefficiency of harvesting is also adding fuel to the fire in certain cases. Some conservation measures like (i) conducting awareness campaigns on the importance and vulnerability of threatened medicinal plants, (ii) implementation of improved harvesting techniques with less mortality of species (iii) establishment of a protected area for threatened medicinal plants in their natural habitat, (iv) extensive efforts for both *in situ* and *ex situ* conservation involving local communities, (iv) establishment of nurseries through the development of propagation and cultivation protocols and (v) large scale cultivation of prioritized medicinal plants for commercial purposes could be adopted to mitigate the problems [16] other than the specific ones discussed below.

Homegardening and cultivation

Kitchengardens and homegardens are common homestead components of the land management system of tribals in northeast India. Generally, the former is used for growing common domestic vegetables but the latter is a mix of domesticated and wild resources. Most of the tribals collect wild plants from the forest adjacent to their villages and cultivate most preferred species in their homegardens [9]. The *Galo* community grow local green vegetables and medicinal herbs in their kitchengarden [61]. Traditional homegardens of *Nyishi* are rich in biological diversity, harbouring many local species including medicinal plants [62]. *Nyishi* and *Apatani* are reported to cultivate 23 and 32 species, respectively in their homegardens [17,56]. In *Apatani* homegardens common vegetables and cereals like, cucumber, millet, pumpkin maize, tomato, lai saag, ginger, soybean, onion, frenchbean etc. as well as perenials like, *Pinus roxburghii* and *Phyllostachys manii* are grown for home consumption [63]. It would be difficult for *Apatani* to continue performing the rich cultural practices for want of different plant products (*Angiopteris evecta, Phyllostachys bambusoides, Calamus acanthospathus, Castanopsis hystrix, Saccharum arundinaceum, Eremocaulon capitatum, Zingiber officinalis* etc. which they conserve and cultivate [11]. *Khampati* are also reported to practice homegardening of selected plants (*Ananas cosmosus*, *Carisa papaya, Citrus medica* etc.) used as medicine [38].

Although plants used for the preparation of traditional medicine are mostly collected from the wilderness, some expert practitioners have their own herbal gardens that supply the useful raw materials [9]. In general, cultivation technique is known to the individuals and community but some scientific organisations have also worked on nursery and plantation techniques for some important plants like, *Asparagus recemosus, Berberis aristata, Curcuma caesia, Desmotrichum fimbriatum, Elaeocarpus sphericus, Embelia ribes, Gmelina arborea, Hemidesmus indicus, Homakomena aromatica, Hydnocarpus kurzii, Rauvolfia serpentina, Rubia manjith, Saraca asoca*, and *Taxus wallichiana* [64].

The *Galo* take special interest in conserving natural flora and undertake special conservation and afforestation programmes for the maintenance of natural vegetation. The violation of rules in conserving natural resources and biodiversity by individuals is punished by imposing fines [61]. *Apatani* customary laws have provisioned for specific punishment for example, the offender has to pay (i) twice the cost of destroyed crops and also a fine of one full grown cow to the village authority for trespassing upon the bamboo grove and damaging the crops (ii) a fine of one full grown female mithun and one medium size mithun for burning bamboo garden/ pine grove with ill intention etc. [65].

Aka tribe practice tree management intended at conservation. They collect the saplings or seeds of certain utility trees like, *Callicarpa arborea, Duabanga grandiflora, Terminalia myrocarpa* etc. and plant them in their homegardens. Certain construction timber trees (*Marcus laevigata, Phoebe* sp. etc.) are felled judiciously, never in excess. *Canarium strictum* is never felled for wood, instead fallen wood is collected from the ground. They value *Brovje* and *Miinyin* (*Xanthoxyllum alatum*) trees and care for them by clearing the surroundings to make them competition free and to allow the tree to grow properly.

The tribes of the state have followed their own ethics which has helped them conserve rare and endangered species. They have good knowledge of locating flora and fauna of rare and endangered category and they have been spreading the knowledge to their fellow tribesmen for their conservation [2]. Two unique examples of individual efforts from an *Adi* woman practitioner and a *Nyishi* healer need to be propagated to the largest extent possible. The former spreads awareness about the domestication of forest species and trains *Adi* woman folk for value addition and marketing. The latter has also domesticated valuable plants and made his own homegarden as a demonstration plot. He has also expanded his network by forming an herbalist association. These self-motivated conservators may be provided policy support for creative management of biodiversity [4,66].

The Galo farmers have been using pathological principles for pest and disease control over the generations. They use *Citrus grandis* (Pummelo) leaves as insecticides and repellents for the control of the rice pest *Leptocorisa oratorius* and house hold ash as a repellent to control pests and diseases of cultivated crops. A number of traditional traps are used to control of rats in the rice fields [61].

Conservation reserve

There is acute pressure on the natural habitat of medicinal plants due to unsystematic collection. The habitat destruction and over-exploitation to meet the demands of illegal trade in medicinal plants [64] has led to the extinction of more than 150 plant species in the wild [67]. Therefore, there should be conservation measures like the establishment of Medicinal Plants Conservation Areas in potential habitat. Medicinal species of important and endemic nature in the region should be protected [16]. Further, local inhabitants need to be aware of conservation and cultivation activities for their socio-economic upliftment. One such example is the Medicinal Plant Conservation Area at Harkhe Tari in Ziro valley maintained by *Apatani*. This came up as a government initiative with cooperation from the community and managed by the villagers in order to conserve some valuable medicinal plants like, *Panax pseudo-ginseng,*

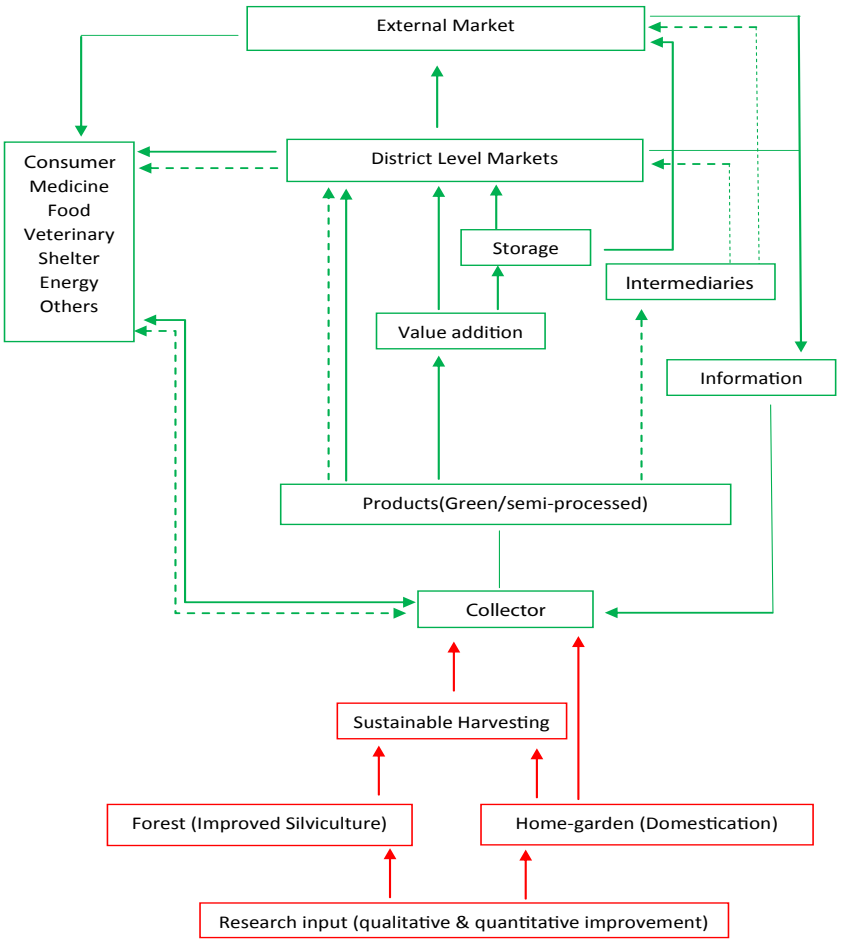

Figure 6: Flow chart depicting current and proposed management of NTFPs in northeastern Himalayan state, Arunachal Pradesh. Dashed arrows indicate current practices while solid arrows are proposed activities intended to improve the livelihood conditions (marketing based, green) and natural resource (conservation and domestication based, red).

Paris polyfolia, Cinnamomum tamala, Cinnamomum zeylanicum, Embelia ribes, Berberis aristata, Rubia manjith etc. [56].

Sacred grove

Throughout India, tribals are known to protect bioresources, plants and animals, owing to religious faith or belief in them. One such common method is the maintenance of sacred groves. These are stands of trees or patches of forests which have remained untouched due to the belief that deities who reside in them bless and protect the local community. The *Apatani* alone have 70 sacred groves in their eight villages. Every clan of the village is known to possess one sacred grove. *Galo* and *Nyishi* are also reported to believe in sacred groves. Other tribes like *Monpa* and *Sherdukpen* who practice Buddhism have sacred groves called *Gumpa* around the monastry. Major species protected in such religious stands of trees are *Albizzia lebeck, Altingia excelsa, Alstonia scholaris, Artocarpus heterophyllus, Artocarpus lakoocha, Bambusa pallida, Bauhunia variegata, Berberis aristata, Callicarpa arborea, Chukrasia tabularis, Dendrocalamus hamiltonii, Ficus bengalensis, Ficus religiosa, Ficus palmata, Lagerstromea indica, Macaranga denticulata, Pandanus spp., Phoebe goalparensis, Phyllanthus emblica, Pinus kesiya, Pterospermum acerifolium, Rubus ellipticus, Syzygium cumini, Tamarindus indica, Trema orientalis, Sauriaria sp.* etc. Murtem and Chaudhry [5] have reported the details of sacred groves of four districts belonging to different tribes. Although this type of conservation may not be useful for commercialization of species but it provides a gene pool to be used at any point of time.

Folk belief and taboo

The tribes of AP, except the converted ones, do not practice prevalent religions of India. However, most of the tribes consider that the forest is the abode of their numerous gods and spirits, both benevolent and malevolent in nature [68]. *Adis* believe that certain trees are the abode of evil spirits, therefore, they do not fell them without performing rituals of sacrificing pig and fowl to appease the spirit. They do not harvest bamboo and cane indiscriminately. Infact big bamboo (*Epoeng*) is cut only on the fourth dark night of full moon as they believe that on a particular day bamboo borer does not attack it. Certain trees like *Tattong, Taapit* and *Tan* have sacred value and are hardly cut as they are believed to be the progeny of the mythical hunter which protects the people from evil spirits. *Ridin* another sacred plant is perceived to ward off evil spirits. *Padam* believe that this plant has emerged from the placenta of the mother of all living beings (*Pedong Nane*) which would guard and protect mankind from any misfortune [69]. They abstain from cutting plants or visiting the

area where bamboo shoots sprout after birth of a child and death funerals in order to save new bamboo shoots from damage [70]. *Hill Miri* do not spit or urinate or throw stones on the sacred plants, such as, *Sigrek Sin* and *Tam* etc. believing that the spirits residing in these plants may bring bad luck to them. The felling of *Jigymu* tree is prohibited for every *Aka* individual of the village and people worship this tree because it is believed that if anyone cuts this tree he would suffer from dreadful diseases. The same is the case with *Syolyen* tree which is believed to inflict skin diseases on any individual who tries to cut it. A tree called *Pyey* is not destroyed by them because of the belief that children might get affected by dysentery, vomiting and swollen tongue [71]. *Aka* also consider forest lands and water resources sacred and believe that interference with such resources results in loss of life. Extraction of resources and hunting are prohibited in high peak mountain since such acts cause nose and mouth bleeding leading to death. Plucking leaves from trees surrounding the sacred pond is also considered taboo because of the fear of losing the way back home [72]. Such concept of sacred pond is also found among the *Khampti* where fishing is strictly prohibited and the pond is used during the most important Buddhist festival called *Sangken*.

Among the *Galo* a tiger hunter cannot consume certain types of birds, fish, meat and he has to even prepare his own food for a month. Also, consumption of certain things like local onion (*Dilap*) and ginger (*Takee*), are taboo for his life time [73]. Similarly, among the *Idu*, in case someone hunts wild animals then he is prohibited from consuming onion, chilli and some leafy vegetables. He cannot touch and use domestic utensils and cannot prepare the meat inside the house.

Conclusion

NTFPs in recent years have gained a remarkable significance throughout the world in determining the rural economy as well as for the conservation of biological diversity, particularly in the tropical regions [74,75]. Though the existing management module with suggested modification is presented in Figure 6, the following points need attention in AP.

Ethnobotanical studies in AP have revealed that with growing urbanization, shrinkage of forest area and the influence of modern culture and education, indigenous food habits of local communities have changed [76]. As a consequence, nutritional quality and unique taste of wild food plants are likely to be neglected. It is the same case with herbal medical care being gradually replaced by modern medicine. Therefore, nutritional quality with medicinal value of the wild plants must be established and promoted with innovative marketing strategy as NTFPs are also extremely critical for the livelihood of the rural poor, and often provide the means to close the income gap with wealthier classes [77]. Quantitative improvement in products through silviculture and homegardening, their value addition and market positioning need to be scaled up for commercial species [31,78].

However, there are many potential risks and dangers in the commercial exploitation of NTFPs. The first is overexploitation and the second is greed for profit by the harvester leading to unsustainable exploitation of species [79]. Unrestrained and unmanaged harvesting is known to have a negative impact on the structure and dynamics of the plant population and this can lead to a decline or even disappearance of a species [80-82]. Currently there are certain species facing vulnerability [16,56]. Therefore, NTFP extraction should be well organized and coordinated with harvest guidelines for the sustainability of extraction. Simultaneously, the traditional knowledge of conservation must be integrated with science- based, professionally managed technology. Since traditional indigenous knowledge in the state is on the decline [56,83], commercialization of NTFPs should be done with utmost care emphasizing on prevention and without compromising on the negative impacts. A key feature of a successful approach to NTFP management would be sound monitoring and evaluation of such a programme [81].

Suplementary Tables

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References

1. Dattagupta S, Gupta A. Non-timber Forest Product (NTFP) in Northeast India: An Overview of Availability, Utilization, and Conservation. Purkayastha J, Editor. In: Bioprospecting of Indigenous Bioresources of North-East India, Springer Science+Business Media Singapore. 2016.
2. Tag H, Das AK. Ethnobotanical notes on the Hill Miri tribes of Arunachal Pradesh, India. Indian Journal of Traditional Knowledge. 2004; 3: 80-85.
3. Tag H, Das AK, Kalita P. Plants used by Hill Miri tribe of Arunachal Pradesh in ethnofisheries. Indian Journal of Traditional Knowledge. 2005; 4: 57-64.
4. Chaudhry P, Dollo M, Bagra K, Yakang B. Traditional biodiversity conservation and natural resource management system of some tribes of Arunachal Pradesh, India. Interdisciplinary Environmental Review. 2011; 12: 338-348.
5. Murtem G, Chaudhry P. Sacred Groves of Arunachal Pradesh: Traditional Way of Biodiversity Conservation in Eastern Himalaya of India. Journal of Biodiversity Management and Forestry. 2014; 3: 1-14.
6. Chakraborty R, De B, Devanna N, Sen S. North-East India an Ethnic Storehouse of Unexplored Medicinal Plants. Journal of Natural Products and Plant Resources. 2012; 2: 143-152.
7. Nimchow G, Tahong T, Hui T, Oyi Dai. Linkages between Bio-Resources and Human Livelihood: A Case Study of Adi Tribes of Mirem Village, Arunachal Pradesh (India). The Initiation. 2008; 2: 183-198.
8. Khongsai M, Saikia SP, Kayang H. Ethnomedicinal plants used by different tribes of Arunachal Pradesh. Indian Journal of Traditional Knowledge. 2011; 10: 541-546.
9. Bharali P, Singh B, Sharma CL. Ethnomedicinal Knowledge of Galo Tribe from Arunachal Pradesh, India. International Journal of Current Research in Biosciences and Plant Biology. 2016; 3: 139-148.
10. Ali N, Ghosh B. Ethnomedicinal plants in Arunachal Pradesh: Some tacit prospects. ENVIS Bulletin: Himalayan Ecology. 2006; 14: 1-7.
11. Bamin Y, Gajurel PR. Traditional use and conservation of some selected Plants used in festivals and rituals in apatani Plateau of Arunachal Pradesh, India. International Journal of Conservation Science. 2015; 6: 189-200.
12. Murtem G, Chaudhry P. An Ethnobotanical Study of Medicinal Plants Used by the Tribes in Upper Subansiri District of Arunachal Pradesh, India. American Journal of Ethnomedicine. 2016; 3: 35-49.
13. Mao AA, Hynniewta TM, Sanjappa M. Plant wealth of India with reference to ethnobotany. Indian Journal of Traditional Knowledge. 2009; 8: 96-103.
14. Srivastava RC, Nyishi C. Traditional knowledge of Nyshi (Daffla) tribe of Arunachal Pradesh. Indian Journal of Traditional Knowledge. 2010; 9: 26-37.
15. Doley B, Gajurel PR, Rethy P, Buragohain R. Uses of trees as medicine by the ethnic communities of Arunachal Pradesh India. Journal of Medicinal

Plant Research. 2014; 8: 857-863.

16. Gajurel PR, Ronald K, Buragohain R, Rethy P, Singh B, Potsangbam S. On the present status of distribution and threats of high value medicinal plants in the higher altitude forests of the Indian eastern Himalaya. Journal of Threatened Taxa. 2015; 7: 7243-7252.

17. Jeri L, Tag H, Tsering J, Kalita P, Mingki T, Das AK. Ethnobotanical investigation of edible and medicinal plants in Pakke Wildlife sanctuary of East Kameng district in Arunachal Pradesh India. Pleione. 2011; 5: 83-90.

18. Nimchow G, Ringu N, Dai NO. Ehnomedicinal knowledge among the Adi tribes of Lower Dibang Valley district, Arunachal Pradesh, India. International Research Journal of Pharmacy. 2012; 3: 223-229.

19. Bamin Y, Gajurel PR, Potsangbam S, Bhuyan LR. Account of common and traditional non-timber forest products used by Apatani tribe of Arunachal Pradesh, India. Pleione. 2013; 7: 514-529.

20. Saha D, Sundariyal RC. Perspectives of Tribal Communities on NTFP Resource Use in a Global Hotspot: Implications for Adaptive Management. Journal of Natural Sciences Research. 2013; 3: 125-169.

21. Perme N, Choudhury SN, Choudhury R, Natung T, De B. Medicinal Plants in Traditional Use at Arunachal Pradesh, India. International Journal of Phytopharmacy. 2015; 5: 86-98.

22. Tilling R, Bharali P, Dutta P, Gogoi G, Paul A, Das AK. Ethnomedicinal plants used by Apatani tribe of Ziro Valley of Arunachal Pradesh. International Journal of Conservation Science. 2015; 6: 411-418.

23. Srivastava RC, Singh RK, Apatani Community, Mukherjee RK. Indigenous biodiversity of Apatani plateau: Learning on biocultural knowledge of Apatani tribe of Arunanchal Pradesh for sustainable livelihoods. Indian Journal of Traditional Knowledge. 2010; 9: 432-442.

24. Murtem G, Chaudhry P. An ethnobotanical note on wild edible plants of Upper Eastern Himalaya, India. Brazilian Journal of Biological Sciences. 2016; 3: 63-81.

25. Angami A, Gajurel PR, Rethy P, Singh B, Kalita SK. Status and potential of wild edible plants of Arunachal Pradesh. Indian Journal of Traditional knowledge. 2006; 5: 541-550.

26. Bhuyan M. Comparative Study of Ethnomedicine among the Tribes of North East India. International Research Journal of Social Sciences. 2015; 4: 27-32.

27. Chakraborty T, Saha S, Bisht NS. First Report on the Ethnopharmacological Uses of Medicinal Plants by Monpa Tribe from the Zemithang Region of Arunachal Pradesh, Eastern Himalayas, India. Plants. 2017; 6: 13.

28. Hussain S, Hore DK. Collection and conservation of major medicinal plants of Arunachal Pradesh. Indian Forester. 2008; 137: 1663-1679.

29. Nimchow G, Rawat JS, Arunachalam A, Dai O. Ethno-medicines of Aka tribe, West Kameng District, Arunachal Pradesh (India). Science and Culture. 2011; 77: 149-155.

30. Goswami P, Soki D, Jaishi A, Das D, Sarma HN. Traditional healthcare practices among the Tagin tribe of Arunachal Pradesh. Indian Journal of Traditional Knowledge. 2009; 8: 127-130.

31. Jha KK. Some Marketing Aspects of Important Non-Timber Forest Products in a Proposed UNESCO Heritage Site of Arunanchal Pradesh, India. Journal of Plant Chemistry and Ecophysiology. 2016; 1: 1007.

32. Kagyung R, Gajurel PR, Rethy P, Singh B. Ethnobotanical plants used for gastro-intestinal diseases by Adi tribes of Dehang-Debang Biosphere Reserve in Arunachal Pradesh. Indian Journal of Traditional Knowledge. 2010; 9: 496-501.

33. Kala CP. Ethnomedicinal botany of the Apatani in the eastern Himalayan region of India. Journal of Ethnobiology and Ethnomedicine. 2005; 1: 11.

34. Kalita J, Khan ML. Medicinal plants from the high altitudes of the western part of Arunachal Pradesh, India and their trade. International Journal of Conservation Science. 2013; 4: 337-346.

35. Namsa ND, Mandal M, Tangjang S, Mandal SC. Ethnobotany of the Monpa ethnic group at Arunachal Pradesh, India. Journal of Ethnobiology and Ethnomedicine. 2011; 7: 31.

36. Rethy P, Singh B, Kagyung R, Gajurel PR. Ethnobotanical studies in Dehang-Debang Biosphere Reserve of Arunachal Pradesh with special reference to Memba tribe. Indian Journal of Traditional Knowledge. 2010; 9: 61-67.

37. Sarmah R. Commonly used Non-Timber Forest Products (NTFPs) by the Lisu tribe in Changlang District of Arunachal Pradesh, India. SIBCOLTEJO. 2010; 5: 68-77.

38. Sen P, Dollo M, Choudhry MD, Choudhry D. Documentation of traditional herbal knowledge of Khampatis of Arunachal Pradesh. Indian Journal of Traditional Knowledge. 2008; 7: 438-442.

39. Srivastava RC, Adi C. Traditional knowledge of Adi tribe of Arunachal Pradesh on plants. Indian Journal of Traditional Knowledge. 2009; 8: 146-153.

40. Yadav AK, Temjenmongla. *In vivo* anthelmintic activity of *Clerodendrum colebrookianum* Walp., a traditionally used taenicidal plant in Northeast India. Parasitology Research. 2012; 111: 1841-1846.

41. Das A, Chaudhury D, Ghate NB, Panja S, Chaterjee A, Mandal N. Protective effect of *Clerodendron colebrokianum* leaves against iron induced oxidative stress and hepatotoxicity in Swiss albino mice. Indian Journal of Experimental Biology. 2015; 53: 281-291.

42. Devi R, Boruah DC, Sharma DK, Kotoky J. Leaf extract of *Clerodendron colebrookianum* inhibits intrinsic hypercholesterolemia and extrinsic lipid peroxidation. International Journal of Pharmatech Research. 2011; 3: 960-967.

43. Doley P, Singh AV, Devi NM, Singh CB, Thokchom A. Reverse phase HPLC estimation of antioxidants and antimicrobial activities of *Clerodendrum colebrookianum* Walp. Journal of Pharmacognosy and Phytochemistry. 2016; 5: 199-205.

44. Paul A, Khan ML, Das AK. Utilization of rhododendrons by Monpas in Western Arunachal Pradesh, India. Journal American Rhododendron Society. 2010; 64: 81-84.

45. Maggioni L. Conservation and Use of Vegetable Genetic Resources: A European Perspective, Proc. XXVI IHC - Advances in Vegetable Breeding. McCreight JD, Ryder EJ, Editors. Acta Horticulturae. ISHS. 2004; 637.

46. Yamaguchi M. World Vegetables, Principle, Production and Nutritive Values. Ellis Horwood Limited Publishers, Chichester, England. 1983.

47. Sundriyal M, Sundriyal RC, Sharma E, Purohit AN. Wild edibles and other useful plants from Sikkim Himalaya, India. Oecologia Montana. 1998; 7: 43-54.

48. Azam FMS, Biswas A, Mannan A, Afsana NA, Jahan R, Rahmatullah M. Are Famine Food Plants Also Ethnomedicinal Plants? An Ethnomedicinal Appraisal of Famine Food Plants of Two Districts of Bangladesh. Evidence-Based Complementary and Alternative Medicine. 2014; 28.

49. Shrivastava S, Jain AK, Tomar RS. Ethnoveterinary practices- a review on phytotherapeutical approaches in treatment of animals. World Journal of Pharmaceutical and Medical Research. 2017; 3: 96-100.

50. Rai PK, Lalramnghinglova H. Ethnomedicinal Plants of India with Special Reference to an Indo-Burma Hotspot Region: An overview. Ethnobotany Research & Applications. 2011; 9: 379-420.

51. Bharati KA, Sharma BL. Some ethnoveterinary plant records for Sikkim Himalaya. Indian Journal of Traditional Knowledge. 2010; 9: 344-346.

52. Tiwari SC, Mahanta D. Ethnological observation on fermented food products of certain tribes of Arunachal Pradesh. Indian Journal of Traditional Knowledge. 2007; 6: 106-110.

53. Odhav B, Beekrum S, Akula U, Baijnath H. Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu-Natal, South Africa. Journal of Food Compound and Analysis. 2007; 20: 430-435.

54. Tangjang S, Borang A, Arunachalam A. Improving Sustenance of Small and Marginal (Adi) Farmers through Traditional Vegetable Crops in East

Siang District of Arunachal Himalaya Northeast India. Indian Journal of Hill Farming. 2014; 27: 90-94.

55. Uprety Y, Poudel RC, Gurung J, Chettri N, Chaudhary RP. Traditional use and management of NTFPs in Kangchenjunga Landscape: implications for conservation and livelihoods. Journal of Ethnobiology and Ethnomedicine. 2016; 12: 19.

56. Jha KK. Non-timber Forest Products, Their Vulnerability and Conservation in a Designated UNESCO Heritage Site of Arunanchal Pradesh, India. Notulae Scientia Biologicae. 2015; 7: 444-455.

57. Sharma D, Tiwari BK, Chaturvedi SS, Diengdoh E. Status, Utilization and Economic Valuation of Non-timber Forest Products of Arunachal Pradesh, India. Journal of Forest and Environmental Science. 2015; 31: 24-37.

58. Nautiyal BP, Pandey N, Bhatt AB. Analysis of vegetation pattern in an alpine zone in north west Himalaya with reference to diversity and distribution pattern. International Journal of Ecology & Environmental Science. 1997; 23: 49-65.

59. Pandey N, Nautiyal BP, Bhatt AB. Studies on vegetation analysis, plant form and biological spectrum of an alpine zone of north-west Himalaya. Tropical Ecology. 2000; 40: 163-166.

60. Baig BA, Ramamoorthy D, Bhat TA. Threatened medicinal plants of Menwarsar Pahalgam, Kashmir Himalayas: Distribution pattern and current conservation status. Proceedings of the International Academy of Ecology and Environmental Sciences. 2013; 3: 25-35.

61. Bora SS, Lahanand JP, Barooah M. Agro - ecological management of natural resource managament of the Galo tribe of Arunachal Pradesh, India. Asian Journal of Environmental Science. 2013; 8: 36-40.

62. Tangjang S, Arunachalam A. Role of traditional home garden system in northeast India. Indian Journal of Traditional Knowledge. 2009; 8: 47-50.

63. Sundariyal RC, Upreti TC, Varuni R. Bamboo and cane resource utilization and conservation in Apatani plateau, Arunachal Pradesh, India: implications for management. Journal of Bamboo and Rattan. 2002; 1: 205-246.

64. Shankar R, Rawat MS. Conservation and cultivation of threatened and high valued medicinal plants in North East India. International Journal of Biodiversity and Conservation. 2013; 5: 572-579.

65. Dutta J, Muang O, Balasubramanian D, Wann FM, Pangging G, Khan ML. The 'Tani' Mega-cultural Landscape. Ramakrishnan PS, Saxena KG, Rao KS, Sharma G, Editors. In: Cultural Landscapes: The Basis for Linking Biodiversity Conservation with the Sustainable Development. UNESCO, New Delhi, India. 2012; 47-58.

66. Singh RK, Srivastava RC. Grassroots biodiversity conservators of Arunachal Pradesh: national recognition and reward. Current Science. 2010; 99: 162.

67. Uniyal SK, Awasthi A, Rawat GS. Current status and distribution of commercially exploited medicinal and aromatic plants in upper Gori valley, Kumaon Himalaya, Uttaranchal. Current Science. 2002; 82: 1246-1252.

68. Choudhury SK. Folk Belief and Resource Conservation: Reflections from Arunachal Pradesh. Indian Folklife. 2008; 28: 4-6.

69. Tayeng P. Role of Forest in the socio-economic life of the Padams of Arunachal Pradesh, [M. Phil dissertation], Arunachal University, Doimukh. 1996.

70. Megu O. Cane and Bamboo in the life of the Adis of Arunachal Pradesh. [M. Phil dissertation], Rajiv Gandhi University, Itanagar. 2007.

71. Nimchow G, Dai O. Traditional management of forest resources by the akas of north - eastern india. Department of Geography, Rajiv Gandhi University, Rono Hills, Doimukh, Arunachal Pradesh (India). Undated.

72. Nimachow G. Forest and Tribe: A study on the Akas of Arunachal Pradesh. [M. Phil dissertation], Arunachal University. Doimukh. 2002.

73. Lollen K. Food Habits of the Galo. [Anthropology dissertation] AITS, Rajiv Gandhi University, Itanagar. 2007.

74. Ros-Tonen M, Dijkam W, Lammerts VBE. Commercial and sustainable extraction of non-timber forest products. Towards a policy and management oriented research strategy, The Tropenbos Foundation, Wageningen, the Netherlands. 1995.

75. Shankar U, Murali KS, Uma Shanker R, Ganeshaiha KN, Bawa KS. Extraction of non-timber forest products in the forests of Bilgiri Rangan Hills, India, 3. Productivity, extraction and prospects of sustainable harvest of amla, *Phyllanthus emblica* (Euphorbiaceae). Economic Botany. 1996; 50: 270-279.

76. Kalita P, Tag H, Sarma HN, Das AK. Evaluation of nutrient potential of five unexplored wild edible food plants from eastern Himalayan biodiversity hotspot region (India). International Journal of Biological, biomolecular, Agricultural, Food and Biotechnological Engineering. 2014; 8: 215-218.

77. Neumann RP, Hirsch E. Commercialization of non-timber forest products: Review and analysis of research. Center for International Forestry Research Bogor, Indonesia. 2000.

78. Schreckenberg K, Marshall E, Newton A, te Velde DW, Rushton J, Edouard F. Commercialization of Non-Timber Forest Products: What Determines Success? ODI Forestry Briefing. 2006; 10.

79. Taylor F, Mateke SM, Butterworth KJ. A holistic approach to domestication and commercialization of non-timber forest products. Leakey RRB, Temu AB, Melnyk M. Vantomme P, Editors. In: Domestication and commercialization of non-timber forest products in agroforestry systems. FAO, Rome. 1996; 75-85.

80. Muraleedharan PK, Sasidharan N, Kumar BM, Sreenivasan MA, Seethalaksmi KK. Non-timber forest products in the western ghats of India: floristic attributes, extraction and regeneration. Journal of Tropical Forest Science. 2005; 17: 243-257.

81. Jimoh SO, Amusa TO, Azeez IO. Population distribution and threats to sustainable management of selected non-timber forest products in tropical lowland rainforests of southwestern Nigeria. Journal of Forestry Research. 2013; 24: 75-82.

82. Dattagupta S, Gupta A, Ghose M. Diversity of non-timber forest products in Cachar District, Assam, India. Journal of Forestry Research. 2014; 25: 463-470.

83. Rechlin MA, Varuni V. A passion for pine: Forest conservation practices of the Apatani people of Arunachal Pradesh. Himalaya, the Journal of the Association for Nepal and Himalayan Studies. 2006; 26: 19-24.

84. Mahanta D, Tiwari SC. Natural dye-yielding plants and indigenous knowledge on dye preparation in Arunachal Pradesh, northeast India. Current Science. 2005; 88: 1474-1480.

85. Deb S, Arunachalam A, Das AK. Indigenous knowledge of Nyshi tribes on traditional agroforestry system. Indian Journal of Traditional Knowledge. 2009; 8: 41-46.

86. Doley B, Gajurel PR, Rethy P, Saikia B. A Check list of commonly used Species by the Nyshi tribes of Papumpare District, Arunachal Pradesh. Journal of Bioscience Research. 2010; 1: 9-12.

87. Kar A. Common wild vegetables of Aka tribe of Arunachal Pradesh. Indian Journal of Traditional Knowledge. 2004; 3: 305-313.

88. Panda S, Srivastava RC. New ethnomedicinal practices by the Akas, Nepalese and Dirang Monpas of West Kameng Districts in Arunachal Pradesh. Indian Journal of Traditional Knowledge. 2010; 9: 721-723.

89. Wangjen K, Chaudhry S, Arya C, Samal PK. A preliminary investigation on ethnomedicinal plants used by Wancho tribes of Arunachal Pradesh, India. Journal of Non-timber Forest Products. 2011; 18: 129-138.

90. Parab RS, Mengi SA. Hypolipidemic activity of *Acorus calamus* L. in Rats. Fitoterapia. 2002; 73: 451-455.

91. Funde SG. Phytochemicals evaluation, anticancer, antioxidant and antimicrobial activity of *Acorus calamus* different solvent extracts. Journal of Chemical and Pharmaceutical Research. 2015; 7: 495-504.

92. Agbafor KN, Engwa AG, Ude CM, Obiudu IK, Festus BO. The Effect of Aqueous Leaf Extract of *Ageratum conyzoides* on Blood Glucose, Creatinine and Calcium Ion Levels in Albino Rats. Journal of Pharmaceutical, Chemical

and Biological Sciences. 2015; 3: 408-415.

93. Ashande MC, Mpiana PT, Ngbolua K. Ethno-botany and Pharmacognosy of *Ageratum conyzoides* L. (Compositae). Journal of Advancement in Medical and Life Sciences. 2015; 2: 1-6.

94. Chauhan A, Rijhwani S. A Comprehensive Review on Phytochemistry of *Ageratum conyzoides* linn. (Goat weed). International Journal of Engineering Technology, Management and Applied Sciences. 2015; 3: 348-358.

95. Majaw S, Moirangthem J. Qualitative and Quantitative Analysis of *Clerodendron colebrookianum* Walp. Leaves and *Zingiber cassumunar* Roxb. Rhizomes. Ethnobotanical Leaflets. 2009; 13: 578-589.

96. Thangi JJ, Ashwini HA, Singh KG. Qualitative and quantitative phytochemical analysis of ethanomedicinal folklore plant- *Clerodendrum colebrookianum*. Journal of Global Biosciences. 2016; 5: 3559-3566.

97. Goswami P, Kotoky J, Chen Z-N, Yang Lu. A sterol glycoside from leaves of *Clerodendron colebrookianum*. Phytochemistry. 1996; 41: 279-281.

98. Devi R, Sharma DK. Hypolipidemic effect of different extracts of *Clerodendron colebrookianum* Walp in normal and high-fat diet fed rats. Journal of Ethnopharmacology. 2004; 90: 63-68.

99. Pawar VA, Pawar PR. *Costus speciosus*: An Important Medicinal Plant. International Journal of Science and Research. 2014; 3: 28-33.

100. Bhattacharya S, Nagaich U. Assessment of Antinociceptive Efficacy of *Costus speciosus* Rhizome in Swiss Albino Mice. Journal of Advanced Pharmaceutical Technology and Research. 2010; 1: 34-40.

101. Rastogi RP, Mehrotra BN. Compendium of Indian Medicinal plants, Central Drug Research Institute, Lucknow and National Institute of Science Communication and Information Resources, New Delhi. 2004; 224-225.

102. Rajesh MS, Harish MS, Sathyaprakash RJ, Shetty AR, Shivananda TN. Antihyperglycemic activity of the various extracts of *Costus speciosus* rhizomes. Journal of Natural Remedies. 2009; 9: 235-241.

103. EL-far AH, Abou-Ghanema II. Biochemical and hematological evaluation of *Costus speciosus* as a dietary supplement to Egyptian buffaloes. African Journal of Pharmacy and Pharmacology. 2013; 7: 2774-2779.

104. Qari SH. DNA-RAPD Fingerprinting and Cytogenetic Screening of Genotoxic and Antigenotoxic Effects of Aqueous Extracts of *Costus speciosus* (Koen.). Journal of King Abdulaziz University: Science. 2010; 22: 133-152.

105. Dubey S, Verma VK, Sahu AK, Jain AK, Tiwari A. Evaluation of Diuretic activity of Aqueous and Alcoholic Rhizomes extracts of *Costus speciosus* Linn in Wister Albino Mice. International Journal of Research in Ayurveda & Pharmacy. 2010; 1: 648-652.

106. Muniyandi SK, Nandanan AT, Veeti SC, Narayanan A, Ganesan B. Studies on Costus speciosus Koen Alcoholic Extract for Larvicidal Activity. International Journal of Pharmacognosy and Phytochemical Research. 2013; 5: 328-329.

107. Donipati P, Sreeramulu SH. Preliminary Phytochemical Screening of *Curcuma caesia*. International Journal of Current Microbiology and Applied Science. 2015; 4: 30-34.

108. Sasikumar B. Genetic resource of Curcuma: diversity, characterization and utilization. Plant Genetic Resource. 2005; 3: 230-251.

109. Damanhouri ZA, Ahmad A. A Review on Therapeutic Potential of *Piper nigrum* L. (Black Pepper): The King of Spices. Medicinal and Aromatic Plants. 2014; 3: 3.

110. Das S, Mondal P, Zaman MK. Curcuma caesia roxb. And it's medicinal uses: a review. International Journal of Research in Pharmacy and Chemistry. 2013; 3: 370-375.

111. Hossain MM, Ahamed SK, Dewan SMR, Hassan MM, Istiaq A, Islam MS, et al. *In vivo* antipyretic, antiemetic, *in vitro* membrane stabilization, antimicrobial, and cytotoxic activities of different extracts from *Spilanthes paniculata* leaves. Biological Research. 2014; 47: 45.

112. Mishra A, Roy S, Maity S, Yadav RK, Keshari AK, Saha S. Antiproliferative effect of flower extracts of *Spilanthes paniculata* on hepatic carcinoma cells. International Journal of Pharmacy and Pharmaceutical Sciences. 2015; 7: 130-134.

113. Morshed MA, Uddin A, Saifur R, Barua A, Haque A. Evaluation of antimicrobial and cytotoxic properties of Leucas aspera and *Spilanthes paniculata*. International Journal of Biosciences. 2011; 1: 7-16.

114. APG III. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Botanical Journal of the Linnean Society. 2009; 161: 105-121.

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