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Non-timber Forest Products, Their Vulnerability and Conservation in a Designated UNESCO Heritage Site of Arunanchal Pradesh, India

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Abstract

The *Apatani,* non-nomadic tribe, have evolved an ecologically sustainable system of rural forestry in Ziro Valley, a proposed heritage site of UNESCO. They have been using non-timber forest products (NTFPs) grown in homestead and nearby forests for a very long period. The present study was aimed at identification of priority NTFPs and uses, their availability status and availability trend, conservation need, and sustainability interventions. Qualitative methods of research like, exploratory survey, questionnaire survey, focus group discussion, semi-structured interview of key informants, etc. were employed for data collection. The *Apatani* used 112 priority NTFPs for food supplement, herbal medicine, house building material and other purposes. However, on the basis of ecological importance such NTFPs were categorized as very low, low, moderate, high, and very high vulnerable species. Twenty vulnerable species like *Antiitari ayi (Actinidia callosa), Biiling (Choerospondias axillaris), Henchi (Rubus niveus), Jojuru ayi (Coccinia grandis), Ngiilyang Khiiko (Centella asiatica)* etc. should be conserved and seventeen not vulnerable species at this stage like, *Padii hamang (Cardamine hirsute), Sankhe (Quercus griffithii), Bije (Phyllostachys manii), Hiigu hamang (Oenanthe javanica), Kiira (Quercus dealbata),* etc. could be commercialized. However, a balance needed to be struck between commercialization and conservation by adopting a comprehensive policy based on scientific and traditional *Apatani* knowledge for harvesting and regeneration of NTFPs. Homegardening or community farming is recommended for sustainable supply of commercially important species to be domasticated.

Keywords: availability status, availability trend, conservation need, homegardening, priority NTFPs, sustainable intervention, vulnerability index

Introduction

A majority of tribal communities in Arunanchal Pradesh depend on forest resources, in the form of non-timber forest products (NTFPs), for their livelihood and daily need. One such community, the *Apatani*, confined to the Ziro Valley of the Lower Subansiri district, is still entirely dependent on forest resources and products for their daily requirement of food supplements (like fruits and vegetables), herbal medicines, dyes, firewood, other household and religious needs (Yakang *et al*., 2013). The *Apatani* have created one of the most intensively cultivated and ecologically sustainable economies in Ziro Valley achieved anywhere in the world (Taylor, 2009). Over the centuries, *Apatani* socio-cultural forms have grown in intricacy, structure and mutual interdependence, as population density, prosperity and intensity of land utilization has grown (Furer-Haimendorf, 1980). They have also evolved an ecologically sustainable system of rural forestry, which not only supports their livelihood by meeting the need for food, fuelwood, timber, fodder and medicine but has also helped in protecting biodiversity (Barua and Slowik, 2000).

The *Apatani* are subsisting on bioresources produced in the Valley and are independent of the outside world for their need of food, medicine, housing material, etc. This self-reliance is the result of a rich traditional ecological knowledge system practiced for the maintenance of a sustainable livelihood (Barua and Slowik, 2000). Their culture, tradition, knowledge about agriculture, forest management system and conservation techniques are so unique and valued that the Valley is proposed as UNESCO heritage site (Dollo *et al*., 2009; Rahman, 2015; Yakang, 2015). However, increasing population, increased exposure to life outside the Valley and adoption of a modern lifestyle may influence the status of NTFPs for financial gain with an inherent risk of commercial exploitation followed by sustainability issue.

Since *Apatani* history developed during several centuries now is getting influenced by the spread of cosmopolitan culture (Rechlin and Varuni, 2006) with suspected impact on self-reliant traditional knowledge and practices of wild resource use, the present study was aimed at gathering information on the NTFPs and their current management practices. The focus was on the identification of priority NTFPs and uses, their availability status and trend, conservation need, and sustainability intervention.

Materials and Methods

Study site

This was an exploratory and qualitative study on collection, consumption and conservation of NTFPs in Ziro (27°33'59"N and 93°49'53"E) Valley in Lower Subansiri district of

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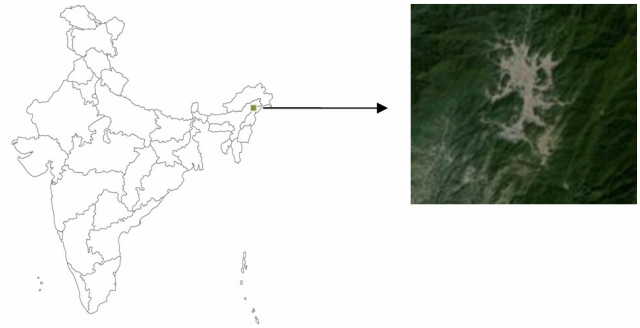

Fig. 1 shows the location of the study site and topographical features of Ziro valley (inset) in Arunanchal Pradesh, India. Courtesy

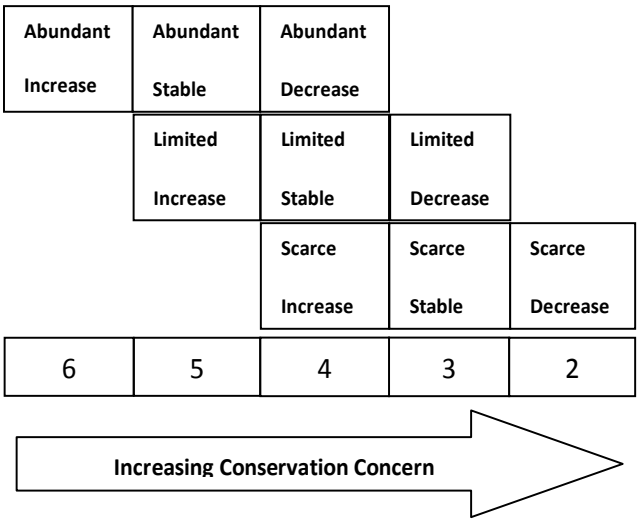

Fig. 2 shows "Conservation Vulnerability Matrix cum index". 6 = very low vulnerability, 5 = low vulnerability, 4 = moderate vulnerability, 3 = high vulnerability and 2 = very high vulnerability

Arunanchal Pradesh (Fig. 1). It has an area of more than 1058 km^2 of which 33 km^2 is under cultivation. A comparatively smaller area is under settlement and the rest is covered by forests and plantations. Ten percent of the forest is under government control (unclassified forest) and the remaining part is with *Apatani* individuals/clans/community. The forest of the Valley is categorized as sub-tropical and temperate climate with a huge diversity of flora and fauna providing diverse NTFPs. The climate is humid sub-tropical to temperate with 235 cm annual rainfall and 1.9 to 28.1 °C temperature variation (Dollo *et al*., 2009).

The Valley is inhabited exclusively by an ethnic group, the *Apatani*, in the villages except some outsiders in the commercial/urban area. Their unique land-use pattern, resource management and culture of conservation have made them a globally significant community (Kumar and Ramakrishna, 1990). Seven major villages that were established many years ago are Hong, Bulla, Hari, Hija, Bamin-Michi, Mudang-Tage and Dutta (Srivastava *et al*., 2010; Dollo *et al*., 2009; Pant, 2000) but a recent article puts the number of villages as thirty five (Yakang *et al*., 2013) which includes some new villages like Biila, Kalung, Lempia, Posumla, Reru, Tajang, etc. Broad landuse pattern for bioresources is in the form of homegarden, bamboo grove, paddy field, and forests. Diverse NTFPs (medicines, eatables, building materials, etc.) grew in all these land parcels.

Methodology

The study was conducted between August 2014 and October 2015. A reconnaissance survey in the new and old villages of Ziro Valley revealed that the younger generation had only superficial knowledge about NTFPs, their use, commercialization, conservation, etc. as compared to older people and some middle-aged professionals who were directly or indirectly involved in NTFP harvesting and utilization. Therefore, the latter category of informants was targeted to collect information about collection, consumption, conservation, etc. of the most important NTFPs. Rechlin and Varuni (2006) had also observed that younger generations were spending less and less time in the forests and forest based activities had become less important for survival. As is often the case with traditional societies, the older generations had more intimate knowledge of their plantations, the uses of various trees and herbs, and of the hunting trails through clan forests. A lot of traditional knowledge was being forgotten or discarded by younger generations, mainly due to scarce communication between young and old people (DAL, 2009).

Altogether 17 sites, old and new villages, were included in this study. Fourteen villages (Andong-Tage, Bami, Bamin-Michi, Biila, Bolya, Hari, Hija, Hong, Kalung, Lempia, Posumla, Reru, Suliya and Tajang) and one urban centre (Hapoli) were examined through survey. The key informants contacted for semi-structured interview represented five villages (Dutta, Hari, Hong, Kalung and Old Ziro). Since older people were more comfortable interacting in their dialect, local interpreters were engaged for the questionnaire and semi-structured interview. The questionnaire was mainly used for village dwellers whose main profession was farming but a few vendors were also included. The selection of respondents as well as villages were random. The semi-structured interview was done with those who were engaged in professions other than farming. The selection of key informants was based on the information provided by the village dwellers during interaction. The interaction was slow and also limited in terms of productivity as the targeted people were engaged in work during the day and were only available in the evening, able to spare little time from their busy evening schedule. However, 45 village residents and nine experts from the *Apatani* community were contacted for questionnaire and semi-structured interview, respectively.

Almost all the respondents provided the vernacular name of the NTFPs. A taxonomist (Dr. P. Gajurel, NERIST, Nirjuli, Arunanchal Pradesh) was consulted for scientific identification of these species. Based on this interaction it was found out that very little work had been done on the taxonomy of plants in the *Apatani* area or Ziro Valley. Inconsistencies were noticed in the transcription of *Apatani* names by the various respondents-interviewees, interviewer and interpreters. This was a result of the absence of a standardized written script for the *Apatani* language. In order to counter the inconsistencies in transcription a recently published *Apatani* language dictionary in the Roman script was consulted. However, some of the vernacular names were converted to scientific names using the literature (DAL, 2009; Srivastava *et al*., 2010; Yakang *et al*., 2013) and by contacting the local Forest Officers (Rinya K. And Tachang N.) and the Chairman, Biodiversity Management Committees of Ziro Valley (Hibu Tatu, Mudang Challyang and Taru Palo).

While assessing the availability status of the same NTFP in Ziro Valley,the respondents gave different opinions. Based on this qualitative assessment (solely perception of the respondents)

they could be divided into Abundant, Limited and Scarce categories. It was perceived by the author during the interaction that the villager's assessment was based on the availability of the NTFPs in their area (community forest or home gardens) not the whole Valley. Therefore, these assessments were quantified into 3, 2 and 1, respectively. The values were averaged out and rounded off to find out actual category of availability status of a particular NTFP (for e.g. >2.5 was Abundant, >1.5 to <2.5 was Limited and = or <1.5 was Scarce). A similar method was adopted for the availability trend with respect to the past 10-15 years, and they were classified in the following categories: Increase, Stable and Decrease. Since availability status and availability trend both influenced the priority of conservation of a species, a "Vulnerability Index" was developed by combining these two parameters into nine different sets and giving them total scores (e.g. 3+3=6 to Abundant-Increase; 1+1=2 to Scarce-Decrease). These sets were further grouped on the basis of total scores: 6, 5, 4, 3, and 2 and presented in the form of a matrix as depicted in Fig. 2.

Results and Discussion

The questionnaire survey revealed that 96% of the respondents were using NTFPs produced in Ziro Valley. Information from some of the key informants and village elders (*Gaonburas*) revealed that NTFPs grew in and were collected from kitchen gardens, Bamboo (*Bije*) groves, bunds of paddy fields (*Lengo Aji* and *Ado Aji*), homegardens (*Yorlu*), and individual/clan/village/community forests (*Morey*). These parcels of land were found in an almost definite pattern with reference to the settlement (Fig. 3) and at a tentative distance (pers. comm. Tasso Sira). While kitchen gardens were currently maintained for growing mostly exotic vegetables and fruits, barring a few indigenous species, community forests were the main source of indigenous NTFPs. Altogether 112 products of non-timber nature were reported to be used by the *Apatani* community for different purposes like food supplement, medicine, house construction materials, etc. (Table 1). Many other NTFPs used by them during social customs and rituals were excluded from the text except of those with high emphasis. However, out of all the prioritized NTFP species only 89 could be identified with scientific names. They were of different categories like food plants, medicinal plants, construction material yielding plants and others. Some of them were found common in earlier reported researches like Yakang *et al.* (2013) where 61 common traditional species were used by Apatani. Also Srivastava *et al.* (2010) declaired 33 species of indigenous biodiversity from Apatani plateau and last but not the least Kala (2005) found 27 ethnomedicinal plants of the Apatani. Literature review also suggested that these species were distributed beyond Ziro Valley, even in the same (Subansiri) or more districts (Changlang, Dibang, Kameng, Lohit, Siang, Tawang, Tirap) of Arunanchal Preadesh (BSI, 1996; 2008; 2009) and some of them were used by other tribes for food or medicinal purposes (Kagyung *et al*., 2010; Rethy *et al*., 2010; Doley *et al*., 2015). These plants were classified among Dicotyledons (Acanthaceae, Aconitaceae, Actinidiaceae, Amaranthaceae, Anacardiaceae, Apiaceae, Araliaceae, Asteraceae, Begoniaceae, Berberdaceae, Brassicaceae, Caprifoliaceae, Cucurbitaceae, Elaeagnaceae, Euphorbiaceae, Fagaceae, Lamiaceae, Lauraceae, Magnoliaceae, Moraceae, Myricaceae,

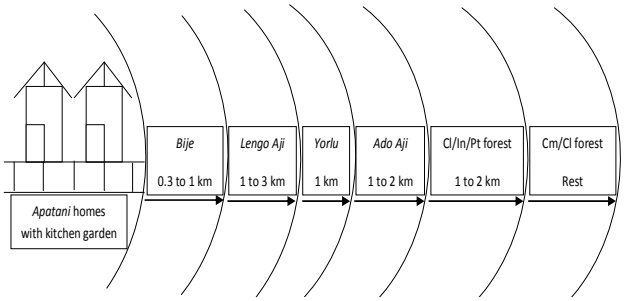

Fig. 3. Land use pattern in Ziro Valley. Cl-Clan, In-Individual, Pt-Private, Cm-Community

Oleaceae, Oxalidaceae, Piperaceae, Plantaginaceae, Poligonaceae, Rhamnaceae, Rosaceae, Rubiaceae, Rutaceae, Saururaceae, Solanaceae, Symplocaceae, Theaceae, Urticaceae, Verbenaceae), Monocot (Arecaceae, Dioscoreaceae, Poaceae, Liliaceae), Gymnosperm (Pinaceae, Taxaceae) and Pteridophyte (Athyriaceae, Gleichaniaceae) families. Kala (2005) working on ethnomedicinal plants of Apatani also reported some of these as dominant families of medicinal plants (Acanthaceae,Asteraceae, Lamiaceae, Rosaceae, Rutaceae, Solanaceae, Urticaceae, and Verbenaceae). Other dominant families in the same area reported by Yakang (2015) are Lauraceae, Magnoliaceae, Rubiaceae, Poaceae, Aeraceae etc.

Priority NTFPs

The staple food of the *Apatani* was rice and fish produced in the Valley which was supplemented by wild fruits and vegetables. Wild plant materials were used for health care. Traditional homes were also constructed by materials produced in the community/clan/individual forests and homegardens. The *Apatani* tribe used a large number of wild NTFPs to meet their diverse requirement and this was possible largely due to the prevalence of a diversity of vegetation in that area (Katewa, 2003). Priority-NTFPs used and identified by them during the present study were 61 species of food supplement, 27 species of medicine, 15 species of construction materials and 9 species of other uses (Table 1). However, all the priority NTFPs identified during the present study were coming either from the forests or homegardens for consumption of the products by the producers directly in the form of green fruits/vegetables /other plant parts or semi-processed/dry form after storage. They were also sold in the market in both fresh and dry form for the consumption of non-producers. Details of the flow of the NTFPs like, production and collection, and disposal through sale are presented in Fig. 4. It was apparent that majority of the products were collected from the forests as compared to home gardens. It was also evident that large number of products was consumed fresh probably day by day. This indicated that the *Apatani* managed their forests and homegardens aiming directly at NTFP collection and indirectly achieving environmental functions like carbon storage, nutrient cycling, erosion control and hydrological regulation (Myers, 1988; Gillis, 1992).

In Ziro Valley, more than 270 NTFPs of plant origins, mostly wild, have been recorded earlier by different researches (Kala, 2005; Srivastava *et al*., 2010; Yakang *et al*., 2013). However, priority NTFPs identified for the purpose of food supplement, medicine, house construction material and few others during this study stood at only 112, which is much lower in number. These plants were frequently used by the Valley people because of their low cost and local availability. In addition

Table 1: Priority Non Timber Forest Products with vernacular and scientific names, and major use categories.

No	Vernacular name*	Scientific name	Category
1	*Antiitari ayi (Entiitariayi, Antriayi)*	*Actinidia callosa*	Food supplement (Wild Kiwi, fruits eaten raw)
2	*Baching ayi (Bachin ayi)*	*Myrica esculenta*	Food supplement (Fruits eaten raw) / Medicine
3	*Biiling*	*Choerospondias axillaris*	Food supplement (Fruits eaten raw)
4	*Bije*	*Phyllostachys bambusoides or P. manii etc.*	Construction material (Mainly in house construction)
5	*Byako(Puro & Ami)*	*Solanum myriacanthum, S. kurzi*	Food supplement (Fruits used as vegetable)
6	*Byapu*	*Phyllostachys manii*	Food supplement (young bamboo shoot eaten)
7	*Byukhu*	*Begonia roxburghii*	Other (Tuber used with *Rubia manjith* produce dye)
8	*Enging (Engin)*	*Dioscorea hamiltonii*	Food supplement (Edible tuber)
9	*Genda haman (Halyan haman)*	*Crassocephalum crepidioides*	Food supplement (Vegetable)
10	*Giyang hamang (Giyan haman)*	*Brassica juncea* var. *rugosa*	Food supplement (Vegetable)
11	*Ginseng***	*Panax pseudoginseng*	Medicine (Plant extract)
12	*Hari ayi*	*Elaiagnus latifolia*	Food supplement (Fruits eaten raw)
13	*Harkhu ayi*	*Actinidia chinensis*	Food supplement (Juicy edible fruits)
14	*Henchi*	*Rubus niveus*	Food supplement (Fruits eaten raw)
15	*Hiihyo hamang*	*Hydrocotyle javanica*	Food supplement (Leaves as vegetable)
16	*Hiihyo lima*	*Hydrocotyle javanica*	Medicine (Medicinal roots)
17	*Hiigu hamang (Hugu haman)*	*Oenanthe javanica*	Food supplement/Medicinal (Vegetable)
18	*Hiika hamang (Hiika)*	*Diplazium esculentum*	Food supplement (Vegetable)
19	*Hiipe*	*Elatostema platyphyllum*	Food supplement (Vegetable)
20	*Hiipe hamang*	*Gonostegia hirta*	Food supplement (Vegetable)
21	*Hiiro hamang*	*Solanum nigrum*	Food supplement (Vegetable)
22	*Imyo (Iimyo)*	*Aconitum ferox*	Medicine /Animal poison (Smear used in arrows for hunting)
23	*Imyo (Iimyo)*	*A. heterophylla*	Medicine /Animal poison
24	*Jiling ayi / Jilyun*	*Rubus ellipticus*	Food supplement (Fruits eaten raw)
25	*Jojuru ayi*	*Coccinia grandis*	Food supplement (Fruits eaten raw)
26	*Kheyi*	*Cinnamomum verum*	Food supplement (Spice)
27	*Kiira*	*Quercus dealbata*	Construction material
28	*Kiira ayi*	*Castanopsis hystrix*	Food supplement (Fruit)
29	*Kukulyu hamang (Kukulyolye haman)*	*Artemisia indica*	Medicine (leaf smell inhaling, also eaten as vegetable)
30	*Lam hamang/ Payinglamu hamang*	*Croton roxburghii*	Food supplement/Medicine
31	*Lase*	*Dioscorea bulbifera*	Food supplement (Tuber as vegetable)
32	*Lobyo*	*Circium interpositum*	Others (used for local salt making)
33	*Luli (Luli hamang)*	*Persicaria hartata*	Food supplement (Vegetable/fodder)
34	*Mepi hamang*	*Plantago erosa*	Food supplement (Vegetable/fodder)
35	*Miiji*	*Sageretia filiformis*	Medicine (Smoke of bark and stem)
36	*Ngiilyang khiiko hamang (Ngiilyang khiiko)*	*Centella asiatica*	Medicine (Whole plant, also used as vegetable)
37	*Nikhe (Dalchini**)*	*Cinnamomum spp.*	Medicine (Spice)
38	*Okhui hamang (Okhuyi haman)*	*Oxalis corniculata*	Medicine (Leaves and stem)
39	*Padii hamang*	*Cardamine hirsuta*	Medicine
40	*Pato hamang*	*Clerodendrum colebrookianum*	Food supplement (Vegetable)
41	*Pato hamang*	*Clerodendrum glandulosum*	Medicine (Leaves, also used as vegetable)
42	*Payu*	*Balanophora dioca*	Others (Gum used for trapping birds, rats)
43	*Pecha*	*Pyrus pashia*	Food supplement/ medicine (Fruits eaten raw)
44	*Pepu*	*Phragmites karka*	Construction material
45	*Piirii*	*Leporsia curnallta*	Medicine
46	*Piitta ayi (Pita ahi)*	*Pyrus calleryana*	Food supplement (Fruits eaten raw)
47	*Raru hamang (Raru, Rari, Rare)*	*Piper pedicellatum*	Food supplement/ Medicine (Vegetable)
48	*Riiko*	*Gynostemma pedata*	Medicine (Dried stem powder)
49	*Sadi* (Pine seedlings)	*Pinus wallichiana*	Other
50	*Saha* (Branches of pine)	*Pinus wallichiana*	Other
51	*Salyo*	*Magnolia champaca*	Medicinal /Constructional Material (Fruits eaten raw, timber for construction)
52	*Salyo ayi*	*M. oblonga*	Food supplement (Fruits used to make local "chutney", yields firewood)
53	*Samper ayi*	*Phoebe goalparensis*	Food supplement (Fruits used as vegetable)
54	*Sanii tero*	*Zanthoxylum rhesta*	Food supplement
55	*Sankhe*	*Quercus griffithii*	Food supplement (Cooked fruits are eaten)
56	*Sankho (Sankan melyan)*	*Ligustrum ovalifoliaum*	Construction material (Used as fence material)

57	*Sankhii/Nausakhii*	*Eurya accuminata,*	Others(Leaves used along with *Rubia manjith* as dye)
58	*Sankhii*	*Symplocos paniculata*	Construction material (Stem used for fencing)
59	*Sanko ayi*	*Zanthoxylum* sp	Food supplement
60	*Santero*	*Litsea cubeba*	Medicine (Ripe fruits eaten, also used as spice)
61	*Santi*	*Quercus spp.*	Construction material /Firewood
62	*Santotero (Santetero)*	*Litsea citrata*	Medicine (Fruits used as spice)
63	*Saati (Sati)*	*Pinus wallichiana*	Medicine (Resin, firewood)
64	*Semo ayi (Sembo)*	*Cerasus cerasoides*	Food supplement/ Construction material (Fruits used in making chutney, timber used for fencing)
65	*Siya hamang (Sia haman, sian)*	*Houttuynia cordata*	Food supplement/ Medicine (Shoot and leaf eaten as vegetable, eaten raw also)
66	*Subutute Jilyung (Subu tute)*	*Duchesnea indica*	Food supplement (Fruits eaten raw)
67	*Taaming (Tamin, Tamen)*	*Mahonia napaulensis*	Food supplement (Fruits eaten raw, bark used for obtaining deep yellow dye)
68	*Tiiming (Tabu Taker, Taming)*	*Rubia cordifolia or R. manjith*	Medicine (roots), Stem used as dye
69	*Tagging hamang*	*Strobilanthes helictus*	Food supplement (Young leaves used as vegetable)
70	*Tajar (Tajer)*	*Neomicrocalamus manii*	Construction material (generally in roof making)
71	*Takho*	*Dicranopteris linearis*	Construction material (Used in fences)
72	*Taku ayi* (wild cucumber)	*Cucumis sativa*	Food supplement
73	*Takung ayi*	*Prunus persica*	Food supplement (Fruits eaten raw)
74	*Tale/Talle hamang*	*Allium tuberosum*	Medicine/ Food supplement (Leaves as salad and tuber as medicine)
75	*Tamen, Taming*	*Mahonia acanthifolia*	Food supplement
76	*Tamo ayi*	*Rhus chinensis*	Medicine (Fruits eaten raw)
77	*Tape (Epe) hamang*	*Cucurbita moschata*	Food supplement
78	*Tapyo*	*Cyanthillium cinereum*	Food supplement (also used in salt making)
79	*Tarko*	*Phyllanthus* sp	Medicine (Antiseptic)
80	*Taro ayi*	*Ficus auriculata*	Food supplement (Fruits eaten raw)
81	*Taxus***	*Taxus baccata*	Medicine
82	*Tayi hamang*	*Amaranthus tricolor*	Food supplement (Leaves and stem used as vegetable)
83	*Tibe*	*Saccharum* sp.	Construction material
84	*Tiire (Tiipe Tiire, Lobyo Tiire)*	*Berberis wallichiana*	Medicine (Thorns used for tattooing/Bark medicinal)
85	*Yabing (Yabing yasi)*	*Eremocaulon capitatum*	Medicine (Young shoot edible)
86	*Yodey*	*Plectranthrus japonica*	Medicine (Leaf juice used for wound)
87	*Yorkhung (Yorkhum)*	*Zanthoxylum armatum*	Medicine (Dried fruits used as medicine, also as spice)
88	*Yoyo (Yoyu)*	*Vibrunum foetidum*	Food supplement (Fruits eaten raw)
89	*Yaso* (cane)	*Calamus floribunda*	Construction material
90	*Ayapakhe/ Ayopakhe haman ≡ Ayo tape hamang (Pumpkin)*	Unidentified	Food supplement (Fruits and leaves eaten as vegetable)
91	*Diiransankhan*	Unidentified	Other (Gum)
92	*Hiibin*	Unidentified	Construction material (Thorny bamboo variety)
93	*Hillang Tai hamang ≡ Tai hamang*	Unidentified	Food supplement
94	*Hiilya hamang*	Unidentified	Food supplement
95	*Hiipehilya hamang* (Type of *Hiilya hamang)*	Unidentified	Food supplement
96	*Kung ayi (Khung)*	Unidentified	Food supplement (Fruit)
97	*More Taki (≡ Payu)*	Unidentified	Other (Gum)
98	*Ngerii piisa*	Unidentified	Construction material
99	*Niming*	Unidentified	Other
100	*Pabo korna ayi*	Unidentified	Food supplement
101	*Pachu koyu hamang*	Unidentified	Food supplement (Leafy vegetable)
102	*Pantai ayi* (Gourd variety)	Unidentified	Food supplement
103	*Phoh (Poh)*	Unidentified	Medicine (Wild aromatic grass)
104	*Pinchu sai ayi*	Unidentified	Construction
105	*Pinging*	Unidentified	Others (used for local salt making)
106	*Puditaru*	Unidentified	Medicine
107	*Pumi haman*	Unidentified	Food supplement
108	*Riiying/ Ruhin/ Riihing*	Unidentified	Construction material
109	*Sanchi*	Unidentified	Food supplement
110	*Siioeng hiika*	Unidentified	Food supplement
111	*Tai hilang San*	Unidentified	Other (Wood used as axe handle/tools)
112	*Tapang*	Unidentified	Other

*Names differ from one village to another;
** Non-*Apatani* names

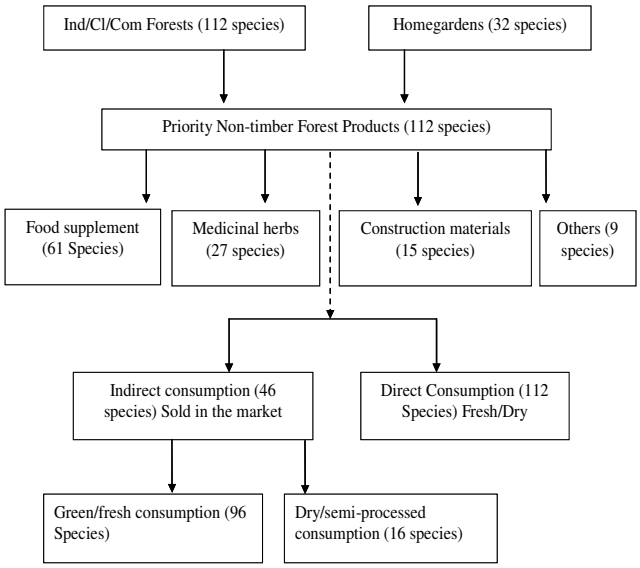

Fig. 4. Production and consumption pattern of Priority NTFPs of Ziro Valley. Ind = individual, Cl = clan, Com = community, Forests

to these, the inadequate provision of modern medicine and food alternatives as well as various cultural and religious reasons were also important factors (Shanley and Luz, 2003). A few key informants reported that in the last few decades the use of the NTFPs had multiplied as the selling of the products had increased in the market. This may, in the long run, have a negative impact on sustainable harvesting as opined by Ingram and Bongers (2009). This is to say that when the wild plants move from subsistence use to commercialization, the economic and social livelihoods of harvesters, producers, processors, urban traders and consumers become interlinked through demand and supply interactions that can lead to unsustainable exploitation.

Ecological importance

Different NTFPs (Table 1) used by the *Apatani* were mostly produced in their own forests and homegardens. Many NTFPs were also found in reserved (government owned) forests but these were not freely accessible. Although a majority of NTFPs were growing in community forest, as many as 32 NTFPs {*Baching ayi (Myrica esculenta), Bije (Phyllostachys manii), Giyang hamang (Brassica juncea* var. *rugosa), Hiibyo hamang (Hydrocotyle javanica), Hiilang tai hamang , Hiika hamang (Diplazium esculentum), Jojuru ayi (Coccinia grandis), Kiira (Quercus dealbata), Mepi hamang (Plantago erosa), Miiji (Sageretia filiformis), Ngiilyang khiiko (Centella asiatica), Okhui hamang (Oxalis corniculata), Pachu koyu hamang , Padii hamang (Cardamine hirsuta), Pato haman (Clerodendrum colebrookianum* and *P. glandulosum), Pantai ayi , Pepu (Phragmites karka), Poh/Phoh , Puditaru, Salyo (Magnolia champaca), Sati (Pinus wallichiana,* Resin*), Siya hamang (Houttuniya cordata), Subutute (Duchesnea indica), Tale hamang (Allium tuberosum), Tamin (Mahonia napaulensis), Tamo ayi (Rhus chinensis), Tape hamang (Cucurbita moschata), Tarko (Phyllanthus sp.), Tayi hamang (Amaranthus tricolor), Yaso (Calamus floribunda), Yodey (Amaranthus tricolor)* and *Yorkhum (Zanthoxylum armatum)*} were grown in homegardens for quick access and higher quantity use on a frequent basis. All the NTFP species produced in Ziro Valley were consumed by the Valley dwellers after direct collection and many (46) of them were sold to cater to the need of market dependent people (Table 2). However, some of the commercially important species identified by the key informants were *Antiitari ayi (Actinidia callosa) Baching ayi, Biiling (Choerospondias axillaris), Diiransankhan, Hari ayi (Elaiagnus latifolia), Henchi, Hiibyo lima (Hydrocotyle javanica), Hiigu hamang (Oenanthe javanica), Hiipey hamang (Gonostegia hirta), Kung ayi, Ngliyang khiiko, Taro (Ficus auriculata), Padii hamang, Riiko (Ficus auriculata), Siya hamang, Subutute, Salyo ayi (Magnolia champaca, M. oblonga),Samper ayi (Phoebe goalparensis),etc.*

However, the respondents could assess 79 ecologically important NTFP species on the basis of availability status and placed 21 species in Abundant, 44 species in Limited and 14 species in *Scarce* category (Table 3). Similarly, the availability trend of 58 NTFPs was also assessed by them in the following classification-12 species in Increasing, 24 species in *Stable* and 22 species in *Decreasing* category. These species, have been evaluated for bot parameters and were grouped according to the "Vulnerability Matrix" (Fig. 2) and presented in Fig. 5. After regrouping, as per the vulnerability index, these species could be categorized as follows: (i) Very low vulnerability: *Padii hamang, Sankhe* (*Quercus griffithii*); (ii) Low vulnerability: *Bije, Hiigu hamang, Kiira, Kiira ayi (Castanopsis hystrix), Mepi hamang, Sankho (Ligustrum ovalifoliaum), Semo ayi (Cerasus cerasoides), Siya hamang, Byako (Solanum myriacanthum* and *S. kurzi), Enging (Dioscorea hamiltonii), Lase (Dioscorea bulbifera), Ngerii, Pinchi sai ahi, Tamo ayi, Yabin-bije (Cephalostachium capitatum);* (iii) Moderate vulnerability: *Kukulyu hamang (Artemisia indica), Pachu koyu hamang, Salyo ayi, Sanko ayi (Zanthoxylum* sp*), Tapang, Baching ayi, Hiipe hamang, Hiika hamang, Pecha (Pyrus pashia), Riiko, Santero (Litsea cubeba), Taaming, Taging hamang (Strobilanthes helictus) , Tale hamang, Tamin, Taro ayi, Yorkhum, Bukhe, Pabo kormo ayi, Pumi haman* (iv) High vulnerability: *Antiitari ayi, Ayapakhe hamang, Biiling, Diiransankhan, Henchi (Rubus niveus), Hiibyo hamang, Ngilyang khiiko, Raru hamang (Piper pedicellatum), Samper ayi, Santi (Quercus spp.), Tayi hamang, Yaso-cane, Sanchi, Santutaki, Taku ayi (Cucumis sativa)* and (v) Very high vulnerability: *Hiibin, Imyo (Aconitum ferox* and *A. heterophylla), Jojuru ayi, Khung, More taku, Payu*. The total number of species according to these categories were arranged as per the "vulnerability index" and presented in Fig. 6. Some of these important non-timber products along with others are presented in Fig. 7, Fig. 8 and Fig. 9.

Above NTFPs, along with others, were exploited in the past and their availability status was altered due to harvesting. Currently they were at varying states of vulnerability in terms of need for conservation. This may be due to different intensity of exploitation and methods of extraction and also because of the ability of the species to respond to the extraction. The exploitation of forest resources has a differing effect, depending on the type of species and parts being harvested. Unless harvesting is controlled, some species may become genetically impoverished much more rapidly than others (Arnold and Perez, 2001). Neumann and Hirsch (2000) also concur that large scale harvesting may have ecological effects on NTFPs in the form of negative, positive and even neutral growth. Therefore, looking at the distribution of the species (Fig. 6) it

Table 2. List of NTFPs sold in the market as food supplement, medicine and construction material

SN	Food supplement	Food supplement	Medicine	Construction material
1	*Antiitari ayi*	*Kra ayi*	*Hibiyo lima*	*Kiira*
2	*Baching ayi*	*Lase*	*Miiji*	*Riiying*
3	*Biiling*	*Padii hamang*	*Ngilyang khiiko*	*Santi*
4	*Diiransankhan*	*Pecha*	*Padii hamang*	*Sembo*
5	*Enging*	*Rare haman*	*Pecha*	
6	*Giiyang hamang*	*Sankhi*	*Riiko*	
7	*Hari ayi*	*Salyo ayi*	*Santero*	
8	*Hii/Hiyi*	*Samper ayi*	*Siya hamang*	
9	*Henchi*	*Sanko ayi*	*Tarko*	
10	*Hiigu hamang*	*Siya hamang*	*Tamin*	
11	*Hiika hamang*	*Subututе*	*Yabing yasi*	
12	*Hiiro hamang*	*Takung*	*Yorkhum*	
13	*Hiipey hamang*	*Tape hamang*		
14	*Kheyi*	*Tapyo*		
15	*Kung ayi*	*Taro ayi*		

Table 3. Category wise list of ecologically important NTFPs based on 10-15 years experience of the respondents

No	Availability status			Availability trend		
	Abundant	Limited	Scarce	Increase	Stable	Decrease
1	*Bije*	*Antiitari ayi*	*Bukhe*	*Bukhe*	*Baching ayi*	*Antiitari ayi*
2	*Biyapo*	*Ayapakhe*	*Hiibin*	*Byako*	*Bije*	*Ayopakhe haman*
3	*Byapu*	*Baching ayi*	*Imyo*	*Enging*	*Hiigu hamang*	*Biiling*
4	*Hiigu hamang*	*Biiling*	*Jojuru ayi*	*Lase*	*Hiipey hamang*	*Diiransankhan*
5	*Kiira*	*Byako*	*Khung*	*Ngerii*	*Hiika hamang*	*Henchi*
6	*Kiira ayi*	*Diiransankhan*	*More taku*	*Pabo kormo ayi*	*Kiira*	*Hiibin*
7	*Kukulyu*	*Enging*	*Pabo kormo ayi*	*Padii hamang*	*Kiira ayi*	*Hiibyo hamang*
8	*Luli*	*Hari ayi*	*Payinglamu hamang*	*Pinchi sai ahi*	*Mepi hamang*	*Imyo*
9	*Mepi hamang*	*Henchi*	*Payu*	*Puni haman*	*Pecha*	*Jojuru ayi*
10	*Pachu koyu*	*Hiibyo hamang*	*Puni haman*	*Sankhe*	*Piita*	*Khung*
11	*Padii hamang*	*Pato hamang*	*Sanchi*	*Tamo ayi*	*Riiko*	*Kukulyu*
12	*Piirii*	*Hiipey hamang*	*Santotero*	*Yabin (bije)*	*Sanchi*	*More taku*
13	*Salyo ayi*	*Hiiro*	*Santutaki*		*Sankho*	*Ngilyang khiiko*
14	*Samo*	*Hiika hamang*	*Taku ayi*		*Santero*	*Pachu koyu*
15	*Sankhe*	*Kheyi*			*Santutaki*	*Payu*
16	*Sankho*	*Kung ayi*			*Semo*	*Raru hamang*
17	*Sanko ayi*	*Lase*			*Siya hamang*	*Salyo ayi*
18	*Semo*	*Lum hama*			*Taaming*	*Samper ayi*
19	*Siya hamang*	*Ngerii*			*Taging hamang*	*Sanko ayi*
20	*Takung*	*Ngilyang khiiko*			*Taku ayi*	*Santi*
21	*Yodey*	*Pantari ayi*			*Tale hamang*	*Tayi hamang*
22		*Pecha*			*Tamin*	*Yaso (cane)*
23		*Phoh*			*Taro ayi*	
24		*Pinchi sai ayi*			*Yorkhum*	
25		*Pitta ayi*				
26		*Raru hamang*				
27		*Riiko*				
28		*Samper ayi*				
29		*Santero*				
30		*Santi*				
31		*Sarlang*				
32		*Subututе*				
33		*Taaming*				
34		*Taging hamang*				
35		*Tai hamang*				
36		*Tale hamang*				
37		*Tamin*				
38		*Tamo ayi*				
39		*Tara*				
40		*Taro ayi*				
41		*Yabin (bije)*				
42		*Yaso (cane)*				
43		*Yorkhum*				
44		*Yoyo*				

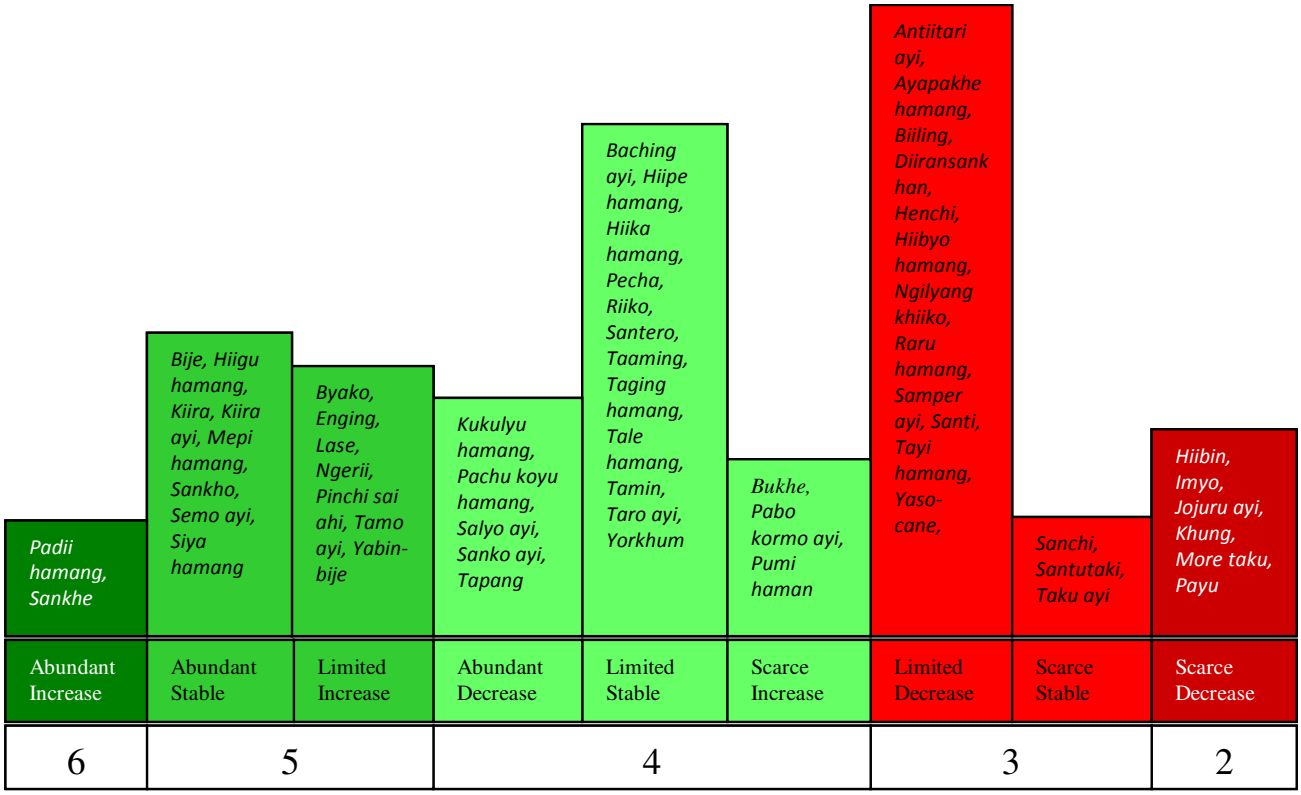

Fig. 5 Group of species as per conservation vulnerability matrix (Abundant-Increase -------> Scarce-Decrease) and index value (6------->2)

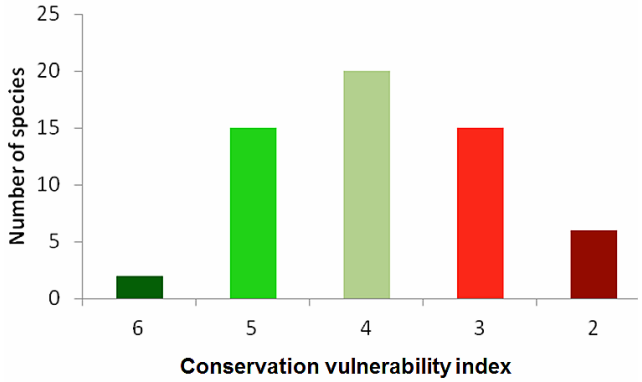

Fig. 6 Species distribution assessed for availability status and availability trend converted to conservation status

could be speculated that with continued exploitation and in the absence of conservation measures this distribution may swing towards vulnerability at least in the case of species in the negative impact category. Currently non-vulnerable species may not be a concern for the villagers but if the NTFP sector is promoted and the demand increases then species-specific management would become critical. The issue of regeneration, cultivation or domestication, sustainable long term supply and harvesting, etc. will need to be addressed simultaneously (Ingram and Tieguhong, 2013).

Conservation need

The NTFPs classified using the vulnerability index (Table 3), need conservation efforts of different levels as they are currently assessed at varying levels of vulnerability. The group of scarcely available plants was *Bukhe, Pabo kormo ayi, Payinglamu hamang, Pumi haman, Sanchi, Santotero, Santutaki and Taku ayi*. The group of plants which showed decreasing trend of availability was *Antiitari ayi, Ayopakhe haman, Biiling, Diiransankhan, Henchi, Hiibyo hamang, Kukulyu, Ngilyang khiiko, Pachu koyu hamang, Raru hamang, Salyo ayi, Samper ayi, Sanko ayi, Santi, Tayi hamang, Tapang* and *Yaso*-cane. The most important group of plants which had scarce availability status as well as decreasing (availability) trend were *Hiibin, Imyo, Jojuru ayi, Khung, More taku and Payu*. These needed utmost care so that they could be saved from disappearance from the Valley in the near future.

The economic benefits of NTFP extraction are viable over time only if collection of the species or groups of species is ecologically sustainable. A maximum sustainable harvest limit implies that the rate at which these parts are taken from a plant or at which individual plants are culled from the population will not exceed the natural/artificial rate of regeneration in a given time period (Stanley *et al*., 2012). Therefore, harvesting without regeneration and the increased marketing of such wild plants may result in decline and reach near-extinction (Ticktin, 2004). Species with great cultural value and economic significance that are at risk of overexploitation and population decline should thus be given top most conservation priority (Hamilton, 2004). Based on their studies on agriculture diversity and conservation of wild plants Norfolk *et al*. (2013) have advocated that smallholder farms and homegardens can be valuable tools in conservation, preserving local species and maintaining ecosystem functioning.

Sustainability intervention

The *Apatani* grew several important species (32) in their homegardens. Some such prominent species were classified on the basis of ecological importance in the following order: Abundant-Increasing: *Padii hamang* (6); Abundant-Stable: *Bije, Kiira, Mepi hamang, Siya hamang* (5); Abundant-Decreasing: *Pachu koyu hamang, Salyo* (4); Limited-Increasing: *Tamo ayi*

Table 4. NTFP matrix indicating management options for different NTFPs based on qualitative evaluation by the Ziro Valley residents

Vulnerability status	Ecologically important NTFPs	Commercially important NTFPs	Domesticated NTFPs	Promotion priority NTFPs	Management option
Very low	*Padii hamang, Sankhe*	*Padii hamang*	*Padii hamang*	*Padii hamang*	Commercialization
Low	*Bije, Hiigu hamang, Kiira, Kiira ayi, Mepi hamang, Sankho, Semo, Siya hamang, Byako, Enging, Lase, Ngerii, Pinchi sai ahi, Tamo ayi, Yabin-bije*	*Siya hamang, Hiigu hamang*	*Siya hamang, Mepi hamang, Bije, Tamo ayi, Kiira,*	*Siya hamang, Mepi hamang, Hiigu hamang, Kiira ayi,*	
Moderate	*Kukulyu, Pachu koyu, Salyo ayi, Sanko ayi, Baching ayi, Hiipey hamang, Hiika hamang, Pecha, Riiko, Santero, Taaming, Taging hamang, Tale hamang, Tamin, Taro ayi, Yorkhum, Bukhe, Pabo korno ayi, Purni haman*	*Salyo ayi, Hiipey hamang, Baching ayi, Riiko, Kung ayi, Biiling, Taro, Anterayi, Hari ayi, Subutute, Hiibyo lima*	*Pachu koyu, Salyo, Baching, Hiika hamang , Tale hamang, Tamin*	*Hiika hamang, Baching ayi, Taro, Tamin, Yorkhum, Hiiro hamang, Luli hamang, Pato hamang, Hari ayi, Kung, Pecha, Piita ayi, Hiibyo lima, Miiji, Riiko,*	Intermediary
High	*Antiitari ayi, Ayapakhe hamang, Biiling, Diiransankhan, Henchi, Hiibyo hamang, Ngilyang khiiko, Raru hamang, Samper ayi, Santi, Tai hamang,Yaso-cane, Sanchi, Santutaki, Taku ayi*	*Diiransankhan, Samper ayi, Henchi, Ngliyang khiiko,*	*Tai hamang, Ngiilyang khiiko, Hiibyo hamang,*	*Antiitari ayi, Rare hamang, Diiransankhan*	Conservation
Very high	*Hiibin, Imyo, Jojuru ayi, Khung, More taku, Payu*		*Jojuru ayi*		

(5); Limited- Stable: *Baching ayi, Hiika hamang , Tale hamang, Tamin* (4); Limited-Decreasing: *Hiibyo hamang, Ngiilyang khiiko, Tayi hamang* (3); Scarce-Decreasing: *Jojuru ayi* (2). Other homegarden species were categorized into the Limited category (*Pato hamang, Poh/Phoh, Subutute*) because their availability trend was not indicated by the respondents. There were some more species of homegarden origin (*Giyang hamang, Hiilang tai hamang, Miiji, Okhui, Pantai ayi, Pepu, Puditaru, Sati (Resin), Tape hamang, Tarko, etc.*) whose availability status or trend was not perceived during survey.

Plant species with local importance and multiple functions have been maintained in traditional homegardens in North-East of India as part of survival over generations with a complex vegetation structure (Tangjang and Arunachalam, 2009). The species grown in homegardens were meant for bulk production and also for reducing the pressure on the community forest. This could be construed as management intervention aimed at keeping the community forest resources as the growing reserve. The productivity could be enhanced further by combining the ecological experience of the villagers with scientific knowledge. An additional benefit of this system was its contribution towards *ex situ* conservation of local plant diversity serving as gene pools of eroding indigenous plant species (Das and Das, 2005; Tangjang and Arunachalam, 2009). Agbogidi and Adolor (2013) have also reviewed the importance of homegardens as conservation units which contain the highest population of some underutilized fruit species. They are *in situ* conservation sites for indigenous varieties of crops. They are also sites for the domestication of wild varieties of some species. They can be used as trial sites for new varieties of some crops and hence can be considered as an entry point for new varieties of crops into the conservation system.

Recently, some community forest areas have been declared as community reserves as part of a government initiative and are managed by the villagers in order to achieve conservation of medicinal plants growing in them. This is one of the measures to protect and harvest NTFPs on a sustainable basis as suggested by Manuel (2005). One such initiative in the Ziro Valley is Medicinal Plant Conservation Area, Harkhe Tari of 200 ha established in 2012. This is intended to conserve very important medicinal plants like, *Panax pseudo-ginseng, Paris polyfolia, Cinnamomum tamala, C. zeylanicum, Embelia ribes, Berberis aristata and Rubia manjith.*

Based on the perception of local stakeholders about the categories of NTFPs a matrix was prepared and presented in Table 4. There are some species (*Padii hamang, Sankhe, Bije, Hiigu hamang, Kiira, Kiira ayi, Mepi hamang, Sankho, Semo ayi, Siya hamang, Byako, Enging, Lase, Ngerii, Pinchi sai ahi, Tamo ayi, and Yabin-bije)* which can be commercialized since their conservation need/priority is very low or low. Out of these *Padii hamang, Mepi hamang, Higu hamang, Siya hamang, and Kiira ayi* are the priority choice to be promoted on a commercial scale. Further, *Padii hamang, Siya hamang, and Hugu hamang* are commercially important species and *Padii hamang, Bije, Mepi hamang, Siya hamang, Tamo ayi, Kiira* have the added advantage of being cultivated in homegardens providing extra security against the negative effects of commercialization. *Padii hamang, Siya hamang, Mepi hamang and Hugu hamang* can be safely recommended for further enhancing the market potential outside the *Apatani* Valley.

In contrast, *Antiitari ayi, Ayapakhe hamang, Biiling, Diiransankhan, Henchi, Hiibyo hamang, Ngilyang khiiko, Raru hamang, Samper ayi, Santi, Tayi hamang, Yaso-*cane, *Sanchi, Santutaki, Taku ayi, Hiibin, Imyo, Jojuru ayi, Khung, More taku, Payu* should be conserved since they have high or very high vulnerability status. Although *Antiitari ayi, Rare hamang, Diiransankhan* are promotion-priority-choice species, *Diiransankhan, Samper ayi, Henchi, Ngliyang khiiko,* are commercially important species and *Tayi hamang, Ngiilyang khiiko, Hiibyo hamang, Jojuru ayi* are homegarden grown species, they should not be promoted for commercialization based on current status. Nevertheless, *Antiitari ayi, Rare hamang, Diiransankhan,*

Fig. 7. Local NTFPs used by *Apatani*. Left to right: first row - Different products in daily market stall and Bamboo shoot; second row - *Hiyi* and *Bije*; third row - *Byako* (*Solanum kurzii*) and *Byako ami* (*Solanum sp*)

Fig. 9. Local fruits consumed by the *Apatani*. Left to right: first row - *Pecha* (*Pyrus pashia*) and *Kiira ayi* (*Castanopsis hystrix*); second row -*Harkhu ayi* (*Actinidia chinensis*) and *Santero* (*Litsea cubeba*); third row -*Pitta ayi* (*Pyrus calleryana*) and *Antitari ayi* (*Actinidia callosa*).

Fig. 8. Leafy NTFP of Ziro Valley. Left to right: first row - *Hiika hamang* (*Diplazium esculentum*) and *Siya hamang* (*Houttuynia cordata*); second row - *Raru hamang* (*Piper pedicellatum*) and *Padii hamang* (*Cardamine hirsuta*); third row -*Ngliyang Khiko* (*Centella asiatica*) and *Giyang hamang (Brassica juncea* var. *rugosa*)

Samper ayi, Henchi, Ngliyang khiiko being commercially important and priority choice species should be managed for recovery first and could be commercialized afterwards.

Conclusions

There are a lot of host plant species used by the *Apatani* as NTFPs with plenty of options in the case of medicine and food supplement. They are locally consumed along with a few, edible and medicinal herbs which have marketing potential as well. NTFP utilization had existed for centuries but it has intensified in the past few decades due to an increase in awareness and demand of the products. Increasing demand can lead people to disregard traditional harvesting techniques. The management of NTFPs must not ignore the local indigenous knowledge, the ecological impact of NTFP extraction, the development of appropriate small scale enterprises and cooperatives for collecting, processing, marketing, monitoring and sharing rights and benefits (Uprety *et al*., 2010).

Natural resources have seen a decrease in availability status and availability trend due to increased exploitation. The increasing demand for natural products in the sectors of food and medicinal ingredients poses major ecological and social challenges. High pressure on wild resources is threatening the survival of populations and species while also endangering local ecosystems. Overharvesting of selected plants for commercialization, premature collection along with habitat destruction, open grazing, forest fire and soil erosion are major threats to the sustainability of NTFP conservation (Famuyide *et al*., 2013). Unrestrained and unmanaged harvesting is known to have a negative impact on the

structure and dynamics of the population and this can lead to the decline or even disappearance of a plant species (Muraleedharan *et al*., 2005; Jimoh *et al*., 2013; Dattagupta *et al*., 2014).

Conservation measures are to be taken to ensure sustainability in production and supply. An appropriate policy framework for a sustainable promotion of NTFPs, domestication of NTFPs, improving harvesting, and processing techniques is necessary to facilitate food security, reduction of poverty, and improved livelihoods (Ahenkan and Boon, 2011). Therefore, domestication or homegardening needs to be encouraged. It is widely accepted that the indigenous knowledge is a powerful resource in its own right and complementary to the knowledge available from western scientific sources. By combining the ecological wisdom of the villagers with scientific knowledge higher productivity of homegardens may be achieved without causing substantial environmental degradation (Denevan, 1995; Milate-Mustafa, 2000).

The selection of potential species can be done based on local priority as most of the wild edible species have high nutritional value. Therefore, it seems imperative to carry out studies on the nutritional values of these plants (Angami *et al*., 2006). Based on the current status of conservation *Padii hamang, Siya hamang, Mepi hamang and Hugu hamang* is recommendable for marketing. *Antiitari ayi, Rare hamang, Diiransankhan, Samper ayi, Henchi, Ngliyang khiiko* could also be marketed but only after improvement in their current very low or low conservation status.

The literature survey pointed to gaps in literature, which necessitate further studies to assess the importance of wild plants in the daily life of households, market potential of the wild plants, their contribution to the local people's livelihood (Barirega *et al*., 2012) and the response to harvesting. It is recommended that future research should focus on gathering detailed information about selected NTFP species, describing habitats, growth requirement, production level and response to harvesting so that a roadmap could be developed for a sustainable management strategy (Ehlers *et al*., 2003). Simultaneously, a balance needs to be struck between human development and environmental degradation. Further, to address the conflicting demand of commercialization and conservation a comprehensive policy should be adopted (Dattagupta *et al*., 2014). This should be based on scientific and traditional *Apatani* knowledge for harvesting and regeneration of NTFPs keeping in mind a minimal impact on the heritage.

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References

Agbogidi OM, Adolor EB (2013). Applied home gardens in the maintenance of biological diversity. Science Reports 1 (1):19-25.

Ahenkan A, Boon E (2011). Improving nutrition and health through non-timber forest products in Ghana. Journal of Health Population and Nutrition 29(2):141-148.

Angami A, Gajurel PR, Rethy P, Singh B, Kalita SK (2006). Status and potential of wild edible plants of Arunanchal Pradesh. Indian Journal of Traditional Knowledge 5(4):541-550.

Arnold JEM, Perez MR (2001). Can non-timber forest products match tropical forest conservation and development objectives? Ecological Economics 39:437-447.

Barirega A, Tabuti JRS, Van Damme P, Agea JG, Muwanika V (2012). Potential for commercialization and value chain improvement of wild food and medicinal plants for livelihood enhancement in Uganda. Current Research Journal Biological Sciences 4(2):108-116.

Barua KK, Slowik J (2000). Traditional ecological knowledge and community based sustainable natural resource management in the eastern Himalayas - A case study of the apatani tribe. Retrieved 2015 August 30 from http://www.uni-goettingen.de.

BSI (1996, 2008, 2009). Botanical Survey of India. Materials for the Flora of Arunanchal Pradesh. Vol 1, 2, 3. (Ed). Ministry of Environment and Forests. New Delhi.

DAL (2009). Dictionary of Apatani Language (website). Apatani Language Project ed, Retrieved 2015 August 30 from http://www.apatani-language-society.com

Das T, Das AK (2005). Inventorying plant biodiversity in home gardens: A case study in Barak valley, Assam, Northeast India. Current Science 98:155-163.

Dattagupta S, Gupta A, Ghose M (2014). Diversity of non-timber forest products in Cachar District, Assam, India. Journal of Forestry Reasearh 25(2):463-470.

Denevan WM (1995). Prehistoric agricultural methods as models for sustainability. Advance Plant Pathology 11:21-43.

Doley B, Gajurel PR, Rethy P, Buragohain R (2014). Uses of trees as medicine by the ethnic communities of Arunanchal Pradesh, India. Journal of Medicinal Plant Research 8:857-863.

Dollo M, Samal PK, Sundriyal RC, Kumar K (2009). Environmentally sustainable traditional natural resource management and conservation in Ziro valley, Arunachal Himalaya, India. Journal of American Science 5(5):41-52.

Ehlers T, Berch SM, MacKinnon A (2003). Inventory of non-timber forest product plant and fungal species in the Robson valley. BC Journal of Ecosystem and Management, 4(2):1-15. Retrieved 2015 August 30 from http://www.forrex.org/ jem/2003/ vol4/ no2/ art2.pdf.

Famuyide OO, Adebayo O, Bolaji-Olutunji KA, Awe F, Owoeye AY, Awodele DO, Adeyemo A (2013). Assessment and sustainable management of non-timber forest products used as food and medicine among urban dwellers in Oyo State, Nigeria. Journal of Horticulture and Forestry 5(11):186-193.

Furer-Haimendorf C (1980). A Himalayan Tribe: From Cattle to Cash. Berkeley: University of California Press.

Gillis M (1992). Economic policies and tropical deforestation. In: Nepstad, D.C. Schwartzman S. (Eds), Non-timber products from tropical forests: evaluation of a conservation and development strategy. Advances in Economic Botany 9:129-142.

Hamilton AC (2004). Medicinal plants, conservation and livelihoods. Biodiversity Conservation 13(8):1477-1517.

Ingram V, Bongers G (2009). Valuation of Non-Timber Forest Product Chains in the Congo Basin: A methodology for valuation. CIFOR. Yaounde, Cameroon, FAO-CIFOR-SNV-World Agroforestry Center-COMIFAC p 80.

Ingram V, Tieguhong JC (2013). Bars to jars: Bamboo value chain in Cameroon. Ambio 42:320-333.

Jimoh SO, Amusa TO, Azeez IO (2013). Population distribution and threats to sustainable management of selected non-timber forest products in tropical lowland rainforests of south western Nigeria. Journal of Forestry Research 24(1):75-82.

Kala CP (2005). Ethnomedicinal botany of the Apatani in the eastern Himalayan region of India. Journal of Ethnobiology and Ethnomedicine 1:11 doi:10.1186/1746-4269-1-11.

Kagyung R, Gajurel PR, Rethy P, Singh B (2010). Ethnomedicinal plants used for gastro-intestinal diseases by Adi tribes of Dehang-Debang Biosphere Reserve in Arunanchal Pradesh. Indian Journal of Traditional Knowledge 9(3)496-501.

Katewa SS (2003). Contribution of some wild food plants from forestry to the diet of tribal of southern Rajsthan. Indian Forester 129(9):1117-1131.

Kumar A, Ramakrishnan PS (1990). Energy flow through an Apatani village ecosystem of Aranuchal Pradesh in north-east India. Human Ecology 18:315-336.

Manuel RP (2005). Poverty alleviation and forest conservation: The role of NTFPs. In: Pfund J, Robinson P (Eds). Non-timber forest products between poverty alleviation and market forces, trees and forests in development cooperation pp 8-13.

Milate-Mustafa M, Hall JB, Teklehaimanot Z (2000). Indigenous management techniques in Bangladesh homegardens. International Tree Crop Journal 10:215-228.

Muraleedharan PK, Sasidharan N, Kumar BM, Sreenivasan MA, Seethalaksmi KK (2005). Non-timber forest products in the western ghats of India: floristic attributes, extraction and regeneration. Journal of Tropical Forest Science 17(2):243-257.

Norfolk O, Eichhorn MP, Gilbert F (2013). Traditional agricultural gardens conserve wild plants and functional richness in arid South Sinai. Basic and Applied Ecology 14:659-669.

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

Pant R (2000). Apatani valley, Lower Subansiri. CCA/Arunanchal/CS1/Lower Subansiri/apatani/ sustainable forest and agriculture management. Retrieved 2015 March 28 from http://www.kalpavriksh.org/images/CCA/Directory/Arunachal_CaseStudy_ApatanivlyLower Subansiri.pdf.

Rahman M (2015). Management of habitat: Change and continuity in Apatani valley. Journal of International Academic Research for Multidisciplinary 3(3):119-125.

Rechlin MA, Varuni V (2006). 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 26(1):19-24.

Rethy P, Singh B, Kagyung R, Gajurel PR (2010). Ethnobotanical studies of Dehang-Debang Biosphere Reserve of Arunanchal Pradesh with special reference to Memba tribe. Indian Journal of Traditional Knowledge 9(1):61-67.

Shanley P, Luz L (2003). The impacts of forest degradation on medicinal plant use and implications for health care in Eastern Amazonia. Bioscience 53(6):573-584.

Srivastava RC, Singh RK, Apatani Community, Mukherjee RK (2010). Indigenous biodiversity of *Apatani* plateau: Learning on biocultural knowledge of *Apatani* tribe of Arunanchal Pradesh for sustainable livelihoods. Indian Journal of Traditional Knowledge 9(3):432-442.

Tangjang S, Arunachalam A (2009). Role of traditional home garden system in northeast India. Indian Journal of Traditional Knowledge 8(1):47-50.

Taylor B (2009). Grounds for democratic hope in Arunachal Pradesh: Emerging civic geographies and the reinvention of gender and tribal identities. In: Sanjib Baruah (Ed), Beyond counter insurgency: Breaking the impasse in northeast India, New Delhi: Oxford University Press pp 308-328.

Ticktin T (2004). The ecological implications of harvesting non timber forest products. Journal of Applied Ecology 41:11-21.

Uprety Y, Boon EK, Poudel RC, Shrestha KK, Rajabhandari S, Ahenkan A, Tiwari NN (2010). Non-timber forest products in Bardiya district of Nepal: Indigenous use, trade and conservation. Journal of Human Ecology 30(3):148-158.

Yakang B (2015). Studies on non timber forest products and associated indigenous knowledge system of Apatanis in Arunanchal Pradesh. PhD thesis, NERIST, Nirjuli, India.

Yakang B, Gajurel PR, Potsangbam S, Bhuyan LR (2013). Account of common and traditional non-timber forest products used by Apatani tribe of Arunachal Pradesh, India. Pleione 7(2):514-529.