

Agro-diversity of East Siang-Arunachal Pradesh, Eastern Himalaya

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Abstract: Besides cultivation and semi-domestication of crops, *Adi* people collect lot of wild vegetables from nearby forests to meet their daily requirement. Qualitative and quantitative data in the present study were collected through field survey and personal interview using standard questionnaires. Altogether, 152 plant species belonging to 95 genera and 39 families were encountered during the study period. They were broadly divided into three categories as cultivated crops (72), semi-domesticated plants (41) and wild plants (39). Vegetables and pulses formed the most frequent mode of uses followed by spices and condiments, cereals and oil seeds. Species diversity based on the habit of the plant revealed that herbs were the most dominant habit followed shrubs, climbers and trees. Based on the plant part uses, leaves formed the most frequently used part followed by fruits, seeds etc. Cultivation is mainly of sustenance in nature rather than for commercial purposes. Most of the agricultural crops are imported from other states mainly Assam. Hence, commercial and proper cultivation of cultivated crops, semi-domesticated plants without losing the traditional value along with scientific approaches and sustainable collection of wild plants are very essential at this stage for welfare of the society in particular and region in general.

Key words: *Adi* tribe, cultivated crops, East Siang, Eastern Himalaya, North Eastern India, semi-domesticated plants, wild plants

INTRODUCTION

Ever since human beings first began domesticating plants and animals some 12,000 years ago, agricultural biodiversity has played a pivotal role in sustaining and strengthening food, nutrition, and health and livelihood security all over the world. In spite of enormous progress made in enhancing productivity through the sustainable use of genetic resources for food and agriculture, more than 800 million people remain under-nourished (FAO, 2004; Chennai Platform for Action, 2005). There are at least 3000 edible plant species known to man, with merely 30 crops contributing to nearly 95% of the world's calories intake, and only 103 crops are economically important at national level (Cooper *et al.*, 1996). In India most rural communities depend on the wild resources including wild edible plants to meet their food needs during the food crisis, as well as for additional food supplements. The diversity in wild plant species offers variety in family diet and contributes to household food security. Besides growing a few crops, people frequently collect wild edible plants and other plants from natural habitats to meet their subsistence needs (Sundriyal *et al.*, 1998). Though in small numbers, due to market demands some farmers have started growing a few species that are still found in wild habitats. These species are in various stages of domestication (Sundriyal and Sundriyal, 2003). The contributions made to the food supply of farm

households by wild plants and semi-domesticates vary enormously from region to region.

There are 1532 edible wild food species in India, mostly from Western Ghats and Himalayan regions (Arora and Pandey, 1996). The Himalayan region is comprised of a large variety of wild-growing plants that are used for food and other subsistence needs by the local communities (Sundriyal and Sundriyal, 2003). Modern agricultural technology and marketing have caused a reduction in the genetic diversity of plant species, especially in vegetables, worldwide (Sun and Hang, 1998; Hang *et al.*, 1998). However, it is clear that many wild species, varieties and animal breeds have the potential to become conventional foods of the future-useful parents in breeding programs; and will be a convenient sources of income; and the vehicles for improved nutrition and increased food supply (Toledo and Burlingame, 2006). They are a cheap source of nutrients and could be useful in formulating balanced diets. Use of wild edible plants as a supplementary food resource holds promise. This aspect needs thorough investigation, so that economically important species are promoted for domestication (Sundriyal and Sundriyal, 2003). Wild plants show that they have a very high nutritional potential, and their nutritional value is greater than that of some green cultivated vegetables (Yildirim *et al.*, 2001; Thayer, 2006). Wild plant species provide minerals, fiber, vitamins and essential fatty acids and enhance taste and

colour in diets. In addition, they have anti-bacterial, hepatoprotective and anticarcinogenic properties, and therefore having medicinal values (Heywood, 1999). Wild plants are good source of vitamin C, iron, zinc and crude fiber. Crude fiber is not a nutrient but it still plays a very important role in maintaining good health (Anderson and Bridges, 1998; Kritchevsky, 1998). Despite these advantages, most traditional plant foods are generally uncultivated and underutilized (Grivetti and Ogle, 2003).

Cultivated plants are more or less similar in almost all the part of the world with exceptional presence of lesser known cultivated plants in some regions. Nevertheless, there is lot of variation in semi-domesticated and wild plants used by different societies particularly the tribal. Tribal people mostly eat vegetables of leafy varieties, which grow as wild weeds and depend on such natural products for their food (Sinha and Lakra, 2005). *Adi* is second largest tribal group/community of the Arunachal Pradesh, Northeast India and inhabits the Siang belt (Upper, West and East Siang), Upper Subansiri and Dibang Valley. East Siang district is mostly inhabited by the *Adi* tribe which comprises of a large number of tribal groups (*Minyongs, Padams, Shimongs, Milangs, Pasis, Karkos, Ashings, Pangis, Tangmas* and *Boris*). They traditionally practice shifting and terrace cultivation in the hills and wet rice cultivation in the valleys. Majority of the population live in remote villages and depend on shifting cultivation and forest for their food, shelter and other requirements. Hunting and fishing are also part of their life. Their life is closely mingled with nature. They use many plants in their day to day life. The core diet of the inhabitants of the region is rice, millets, pulses and a wide variety of local semi-domesticated and wild plants. A wide range of wild plants species are used

by the local population in Arunachal Pradesh including many wild green vegetable, leaves, roots and fruits as food. However, proteins requirements are also being supplemented with animal meat; bush meat including birds; and fishes. They developed traditional knowledge using wild plant as food besides cultivating few. These plants are mainly collected from forests. Activities relating with plant collection are primarily done by women folk. Many of these plants find way to homesteads, home gardens and agricultural lands (Srivastava *et al.*, 2010). All these necessitate inventorying the agrodiversity of the region covering cultivated crops, semi-domesticated plants and wild vegetables to take up proper strategies to conserve and sustain the ever increasing human population.

Large number of studies on wild edible plants and related topic of various states of North eastern India had been carried out by many workers (Arora, 1981; Singh and Singh, 1985; Singh *et al.*, 1988; Maikhuri and Gangwar, 1993; Borthakur, 1996; Sundriyal *et al.*, 1998; Sundriyal and Sundriyal, 2003; Kumar, 2003; Samati, 2004; Sundriyal *et al.*, 2004; Kayang, 2007; Tiwari *et al.*, 2010) however, such study on various tribes of Arunachal Pradesh in general (Haridasan *et al.*, 1990; Murtem, 2000; Kohli, 2001; Kar, 2004, 2005; Angami *et al.*, 2006) is meager and on *Adi* tribe is lacking. Due to various physical barriers they have been leading practically a life of seclusion thereby preserving their traditional knowledge intact. So, documentation of their traditional knowledge on cultivated crops, semi-domesticated and wild vegetable plants become a prerequisite. Keeping the gap in consideration, present study was carried out which provide valuable information on cultivated crops,

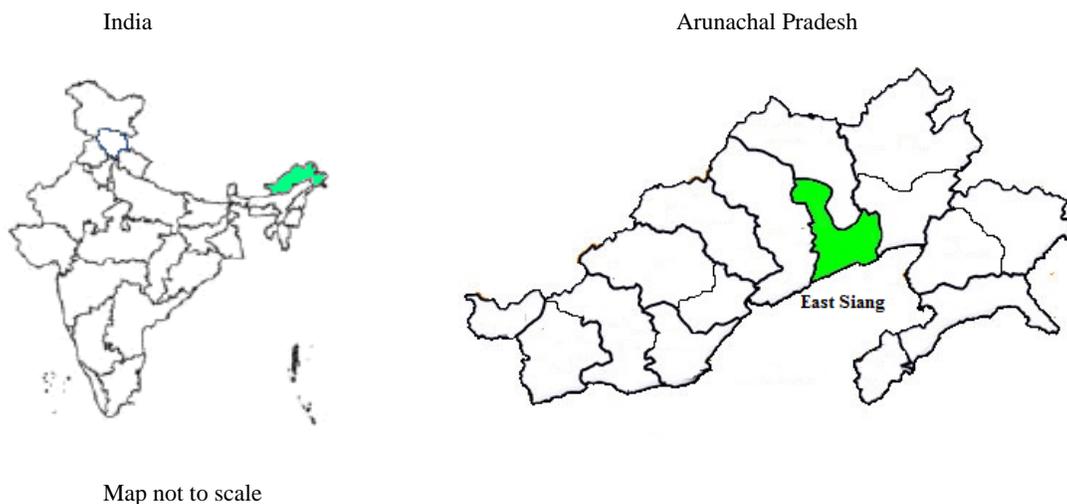


Fig. 1: Map showing study site

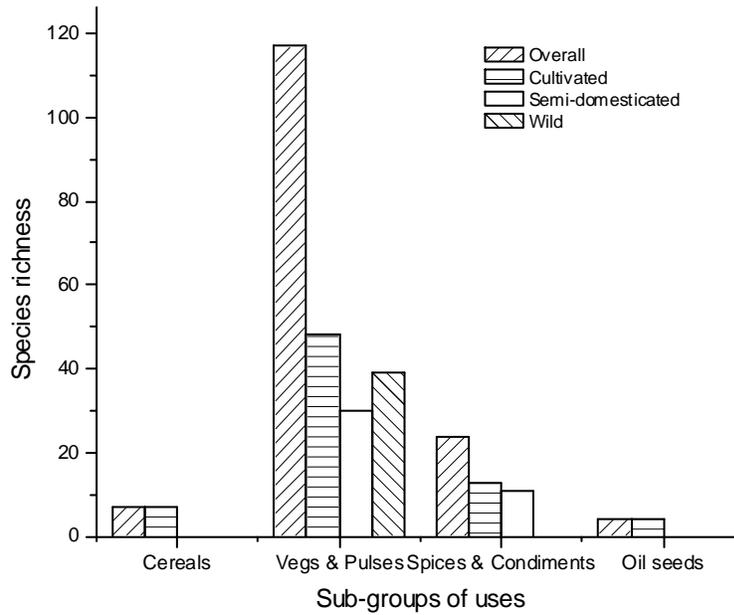


Fig. 3: Species richness per sub-groups under different crop types

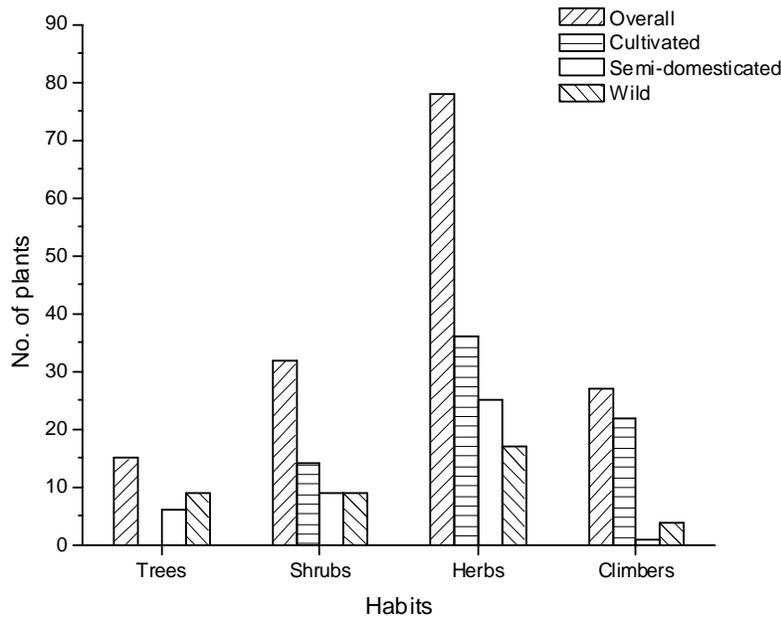


Fig. 4: Agricultural diversity based on habit in different crop types

The present study was based on the methodical field survey conducted during the year 2009 and 2010; and personal interview of local aged 30-70 years of both the sexes using standard questionnaires. Cultivated, semi-domesticated and wild edible plants are collected and identified on the basis of vernacular name, regional floras and published literature (Chowdhery *et al.*, 1996, 2008, 2009; Gajurel *et al.*, 2006; Chauhan *et al.*, 1996;

Srivastava and Adi, 2009). They are discussed under different headings - Cultivated crops, semi-domesticated and wild edible plants.

RESULTS AND DISCUSSION

Agro-diversity: Altogether, 152 plants belonging to 95 genera and 39 families were encountered during the study

period. Based on the species diversity, Brassicaceae (15 species) formed the most diverse family followed by fabaceae, cucurbitaceae, solanaceae and poaceae etc., however about 13 families were monospecific (Fig. 2a). The five most dominant species have contributed to about 42% of the total agricultural diversity of the district. Based on the uses of the species, vegetables and pulses (76.97%) formed the most frequent mode of uses followed by spices and condiments (15.78%), cereals (4.60%) and oil seeds (2.63%) (Fig. 3). The plant species were also categorized in to their form of habit i.e., herbs, shrubs, trees and climbers. The diversity of the species on the basis of habit of the plant revealed that herbs formed the most dominant habit (51.31%) followed shrubs (21.05%), climbers (17.76%) and trees (19.44%) (Fig. 4). The plant species were grouped as per the part used as leaves, fruits, seeds, leaves and shoot, rhizomes etc. Leaves (24.34%) formed the most frequently used part followed by fruits (17.10%), seeds (11.84%), leaves and shoots (8.55%) etc. (Fig. 5). All the plants recorded during the field study were broadly divided into three categories as cultivated crops, semi-domesticated plants and wild plants and presented in Table 1a, b, c.

Cultivated crops: 72 cultivated crops belonging to 20 families were encountered during the study. Cultivated crops were divided into 3 sub-groups-cereals; vegetables and pulses; and spices and condiment. Pulses were included with vegetables because in most of the cases immature pods are taken as vegetables. Cereals were represented by seven species, of which rice forms the major crops in both valleys and hills. Millets are cultivated on hills-both in terrace and jhum land. Millets are mainly used by the tribes for brewing local beer called *Apong*. There were as many as 48 vegetables and pulses including tuberous and rhizomatous crops; 13 plants were spices and condiment; and 4 oil plants (Table 1a). All the mustards (*Brassica* spp.) used as leafy vegetables were also used as spices and condiments and as oil seeds.

Brassicaceae (14) represent the most frequent family, followed by Cucurbitaceae (13), Fabaceae (9), Poaceae (7), Solanaceae (6) etc. (Fig. 2b). Based on the uses of the species, vegetables and pulses (66.66%) formed the most frequent mode of uses followed by spices and condiments (18.05%), cereals (9.72%) and oil seeds (5.55%) (Fig. 3). The plant species were grouped as per their habit such as herbs, shrubs, trees and climbers. On the basis of habit of

Table 1a: List of cultivated plants

Scientific name	Family
Cereals	
<i>Coix lacryma-jobi</i> L., <i>Elusine coracana</i> L., <i>Oryza sativa</i> L., <i>Sorghum vulgare</i> Pers., <i>Setaria italica</i> P. Beauv., <i>Triticum aestivum</i> L., <i>Zea mays</i> L.	Poaceae
Vegetables and pulses	
<i>Abelmoschus esculentus</i> (L.) Moench	Malvaceae
<i>Alocasia macrorrhiza</i> (L.) G. Don, <i>A. indica</i> (Roxb.) Schott, <i>Colocasia esculenta</i> (L.) Schott	Araceae
<i>Benincasa hispida</i> (Thumb.) Cogn., <i>Cucumis sativus</i> L., <i>Cucurbita moschata</i> (Duchesne ex Lam.) Duchesne ex Poir., <i>C. pepo</i> L. <i>C. maxima</i> Duch., <i>Lagenaria siceraria</i> (Molina) Standl., <i>Luffa cylindrical</i> (L.) M. Roem., <i>L. acutangula</i> (L.) Roxb., <i>Momordica cochinchinensis</i> (Lour.) Spreng, <i>Momordica dioica</i> Roxb. Ex. Willd, <i>Momordica charantia</i> L., <i>Trichosanthes dioica</i> Roxb., <i>Trichosanthes anguina</i> L.	Cucurbitaceae
<i>Brassica campestris</i> L. var. <i>sarson</i> Prain, <i>B. campestris</i> L. var. <i>toria</i> Duth. and Full, <i>B. juncea</i> (L.) Czern. and Coss., <i>B. napus</i> L., <i>B. oleracea</i> var. <i>gongyloides</i> Lam. Syn. <i>B. oleracea</i> var. <i>caulorapa</i> L., <i>B. rapa</i> var. <i>rapa</i> L., <i>B. campestris</i> L. Syn. <i>B. rapa</i> L., <i>B. nigra</i> Koch., <i>B. oleracea</i> L. var. <i>Botrytis</i> L., <i>B. oleracea</i> L. var. <i>Capitata</i> L., <i>Raphanus sativus</i> (L.) Urban, <i>Sinapis alba</i> L. Syn. <i>Brassica hirta</i> L., <i>Cajanus cajan</i> (L.) Millsp., <i>Dolichos lablab</i> L., <i>Glycine max</i> (L.) Merr., <i>Phaseolus vulgaris</i> L., <i>Pisum sativum</i> L., <i>Vicia faba</i> L., <i>Vigna umbrellata</i> (Thumb.) Ohwi and Ohashi, <i>V. sesquipedalis</i> (L.) Fruwirth Syn. <i>V. Unguiculata</i> L.	Brassicaceae
<i>Carica papaya</i> L.	Caricaceae
<i>Dioscorea allata</i> L., <i>D. bulbifera</i> L.	Dioscoreaceae
<i>Ipomoea batatas</i> (L.) Poir	Convolvulaceae
<i>Lycopersicon esculentum</i> Mill., <i>Solanum incanum</i> L., <i>S. tuberosum</i> L., <i>S. melongena</i> L.	Solanaceae
<i>Manihot esculenta</i> Crantz.	Euphorbiaceae
<i>Musa paradisiaca</i> L.	Musaceae
<i>Spinacia oleracea</i> L.	Amaranthaceae
Spices and condiments	
<i>Allium cepa</i> L., <i>Allium sativum</i> L., <i>Brassica</i> spp.	Liliaceae
<i>Capsicum annuum</i> L., <i>Capsicum frutescens</i> L.	Brassicaceae
<i>Coriandrum sativum</i> L., <i>Eryngium foetidum</i> L., <i>Foeniculum vulgare</i> Mill	Solanaceae
<i>Cucurma longa</i> L., <i>Zingiber officinale</i> Rose	Apiaceae
<i>Piper longum</i> L., <i>Piper nigrum</i> L.	Zingiberaceae
<i>Trigonella foenum-graecum</i> L.	Piperaceae
Oil seeds	
<i>Brassica</i> spp	Fabaceae
<i>Linum usitatissimum</i> L.	Brassicaceae
<i>Perilla frutescens</i> (L.) Britt	Linaceae
<i>Sesamum orientale</i> L.	Lamiaceae
	Pedaliaceae

Table 1b: List of semi-domesticated crop plants

Scientific name	Family
Vegetables	
<i>Amaranthus spinosus</i> L., <i>A. tricolour</i> L., <i>A. viridus</i> L.	Amaranthaceae
<i>Cardamine hirsute</i> L.	Brassicaceae
<i>Centella asiatica</i> (L.) Urban, <i>Oenanthe javanica</i> (Blume) DC.	Apiaceae
<i>Chenopodium album</i> Bosc. Ex Moq./L.	Chenopodiaceae
<i>Clerodendrum colebrookianum</i> Walp., <i>C. viscosum</i> Vent.	Verbenaceae
<i>Crotalaria juncea</i> L.	Fabaceae
<i>Dendrocalamus hamiltonii</i> Nees and Arn. Ex Munro	Poaceae
<i>Diplazium esculentum</i> (Koenigxretz.) Sw.	Athyriaceae
<i>Elatostema sessile</i> Frost	Urticaceae
<i>Fagopyrum esculentum</i> Moench, <i>Polygonum alatum</i> Buch.-Ham. Ex Spreng., <i>P. chinense</i> L., <i>Rumex maritimus</i> L., <i>R. nepalensis</i> Spreng	Polygonaceae
<i>Gynura crepidioides</i> Benth., <i>Spilanthus oleracea</i> L. Syn. <i>S. acmella</i> (L.) Murr., <i>S. paniculata</i> L.	Asteraceae
<i>Houttuynia cordata</i> Thunb.	Saururaceae
<i>Oxalis corniculata</i> L.	Oxalidaceae
<i>Plantago major</i> L.	Plantaginaceae
<i>Solanum indicum</i> L. Syn. <i>S. anguivi</i> Lam, <i>S. kurzii</i> Brace ex Prain, <i>S. nigrum</i> L., <i>S. spirale</i> Roxb., <i>S. xanthocarpum</i> Schrad and Wendl	Solanaceae
<i>Stellaria media</i> L.	Caryophyllaceae
Spices and condiments	
<i>Allium</i> sp.	Liliaceae
<i>Alpinia</i> sp., <i>Amomum aromaticum</i> Roxb., <i>A. dealbatum</i> Roxb	Zingiberaceae
<i>Cinnamomum bijolghota</i> (Buch.-Ham.) Sweet, <i>Litsea cubeba</i> (Lour.) Pers.	Lauraceae
<i>Murraya koenigii</i> (L.) Spreng, <i>Zanthoxylum armatum</i> DC., <i>Z. burkillianum</i> Babu, <i>Z. rhetsa</i> (Roxb.) DC	Rutaceae
<i>Piper mullesua</i> Don	Piperaceae

Table 1c: List of wild plants

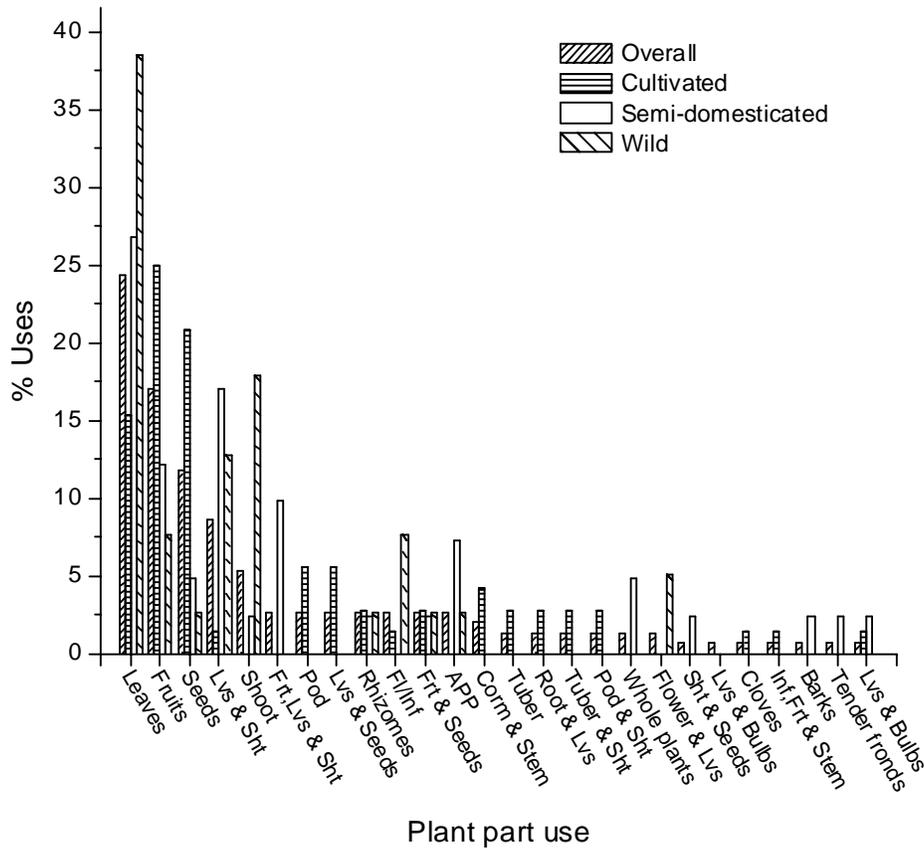
Scientific name	Family
<i>Albizia procera</i> Benth, <i>Bauhinia purpurea</i> L., <i>Bauhinia variegata</i> L., <i>Erythrina stricta</i> Roxb.	Fabaceae
<i>Alpinia malaccensis</i> (Burm. f.) Rosc, <i>Curcuma aromatica</i> Salisb.	Zingiberaceae
<i>Artocarpus chama</i> Buch. -Ham	Lauraceae
<i>Baliospermum calycium</i> Muell.-Arg., <i>Euphorbia hirta</i> L.	Euphorbiaceae
<i>Bambusa balcooa</i> Roxb., <i>Bambusa tulda</i> Roxb	Poaceae
<i>Begonia griffithiana</i> (DC.) Warb., <i>B. josephii</i> A. DC., <i>Begonia palmata</i> D. Don	Begoniaceae
<i>Blumea fistulosa</i> (Roxb.) Kurz., <i>Crepis japonica</i> Benth, <i>Gynura cusimbua</i> (D. Don) S.	Asteraceae
<i>Calamus flagellum</i> Griff., <i>Calamus latifolius</i> Roxb.	Arecaceae
<i>Debregeasia longifolia</i> Burm. f. Wedd., <i>Pilea bracteosa</i> Wedd., <i>Pouzolzia hirta</i> Hassk.	Urticaceae
<i>Dillenia indica</i> L.	Dilleniaceae
<i>Ensete superbum</i> Cheesman, <i>Musa acuminata</i> Colla, <i>Musa balbisiana</i> Colla	Musaceae
<i>Fagopyrum dibotrys</i> (D. Don) H. Hara	Polygonaceae
<i>Hydrangea robusta</i> Hook. F. and Thoms.	Hydrangeaceae
<i>Mussaenda roxburghii</i> Hk. F., <i>Mycetia longifolia</i> (Wall.) O. Ktze., <i>Spiradiclis bifida</i> Wall. Ex Kurz.	Rubiaceae
<i>Oenanthe javanica</i> (Bl.) DC	Apiaceae
<i>Oxalis corniculata</i> L.	Oxalidaceae
<i>Piper sylvaticum</i> Roxb	Piperaceae
<i>Plantago major</i> L	Plantaginaceae
<i>Selaginella wallichii</i> (Hook. and Grev.) Spreng.	Selaginellaceae
<i>Sida acuta</i> Burm. f	Malvaceae
<i>Solanum torvum</i> Sw.	Solanaceae
<i>Trevesia palmata</i> Vis.	Araliaceae

the plant, herbs formed the most frequent habit (50%) followed climbers (30.55 %) and shrubs (19.44 %) (Fig. 4). Fruits (25%) were the most frequently used plants' part followed by seeds (20.83%), leaves (15.27%), pods and leaves & seeds (5.55% each), corm and stems (4.16%) etc. (Fig. 5).

The crop plants include some lesser known crops such as millets, *Dioscorea* spp., *Momordica* spp., etc. Though crops field are highly diversified, productivity is quite low. Their form of agriculture is very traditional, labour bounded and rain-fed. They use indigenous

implements and traditional techniques for agricultural proposes; this might be the result of lesser agricultural output. They use no/very less chemical fertilizers. The use of fertilizer in state is lowest in whole Northeast region (Mishra *et al.*, 2004). For fertility they relied on crop rotation, mixed cropping etc.

Semi-domesticated plants: As many as 41 semi-domesticated plants belonging to 21 families were encountered during the study period, of which 30 plants were used as leafy vegetables and 11 plants which are



* Lvs = Leaves, Sht = Shoot, Frt = Fruit, Fl = Flower, Inf = Inflorescence, APP = Aerial plant part

Fig. 5: Percentages of different plants' part used under different crop types

used as spice or condiment (Table 1b). Polygonaceae and Solanaceae represent the most frequent family, followed by Rutaceae, Amarantaceae, Zingiberaceae etc. (Fig. 2c). Based on the uses of the species, vegetables and pulses (73.17%) formed the most frequent mode of uses followed by spices and condiments (26.82%) (Fig. 3). On the basis of habit of the plant, herbs formed the most frequent habit (60.97%) followed by shrubs (21.95 %), trees (14.63) and climbers (2.43%) (Fig. 4). Leaves (26.82%) were the most frequently used plants part followed by leaves and shoots (17.07%), fruits (12.19% each), fruits, leaves and shoots (4.16%) etc., (Fig. 5).

These plants are in various state of domestication. Integration of wild species into agricultural system will not only protect biological diversity but also provide adequate food and contribute to the rural economy. Domestication grew out of food gathering almost imperceptibly led to cultivation (FAO, 1999). These semi-domesticated plants have been maintained traditionally from time immemorial by the local farmers. This diversity could be a source of germplasm for development of better

hybrid plants. Many of these plants formed the major vegetables of the locals. *Clerodendrum* spp., *Houttuynia cordata*, *Polygonum* spp., *Solanum* spp. and *Spilanthes* spp. were among the most frequently used semi-domesticated vegetables by the locals.

Wild plants: As many as 39 wild plants belonging to 22 families were encountered during the study (Table 1c). Fabaceae (4) represent the most frequent family, followed by Asteraceae, Begoniaceae, Musaceae, Rubiaceae, Urticaceae (3 each), Arecaceae (2) etc. (Fig. 2d). All the species were used as vegetables and pulses (100%) (Fig. 3). On the basis of habit of the plant, herbs formed the most frequent habit (43.58%) followed by shrubs and trees (23.07 and climbers (10.25%) (Fig. 4). Leaves (30.76%) were the most frequently used plants part followed by shoot (17.94%), leaves & shoots (12.82% each), inflorescence (7.69%) etc. (Fig. 5).

Use of large number of wild species by the tribal to meet their diverse requirements is largely due to the prevalence of diversity of vegetable in the area (Katewa,

2003). Although the principle role of these plants is to supplement the food cultivated in home gardens and other forms of agriculture, many of the wild harvested are reported to have both therapeutic and dietary function (Maikhuri *et al.*, 2000; Nautiyal *et al.*, 2003). As in central Himalayas (Maikhuri *et al.*, 2000), wild foods are considered by the local inhabitants in the region as necessity rather than as a supplement and eaten frequently. Households with financial means to purchase cultivated alternatives also reported to consumed wild edible plants. This demonstrates the strong cultural underpinnings of the use of wild edible plants (Cocks and Wiersum, 2003) although the remoteness of the village from markets that supply cultivated species much have a role to play (Rao and Saxena, 1996). The sale from the surplus of their collection adds to their income significantly (Angami *et al.*, 2006).

CONCLUSION

As in other part of the world, agrodiversity in the district is considered to be declining at fast rate. Modern farming is productive no doubt but very fragile from ecological point of view (low heterogeneity). Traditional agricultural systems which are cost effective relying on local resources, friendlier to the environment and more sustainable than modern farming system are gradually abandoned to meet the demand for agricultural products with the population growth. So, instead of diversified crop fields, farmers are now concentrated on few commercially demanded crop plants. If serious view of the existing situation is not taken into account, the district will always remain food importing region and loose badly in terms of ecological and economic security. Furthermore, the region would lose traditional knowledge of cultivation and uses of these crops forever and would also lose the possibility of being a diverse and nutritive food producing region. In situ conservation of the traditional crops and cultivars could succeed when these crops are strongly linked with economic development of the farmers. Effort are being made by the government department of the state of Arunachal Pradesh to formulate an area specific differentiated strategy taking into account the agronomic, climatic, socio economic practices as well as the resource worthiness of the farmer. The resources available are plenty but the ways and means to achieve the objective through gainful utilization of the resources are not well defined. Commercial and proper cultivation of cultivated crops, semi-domesticated plants and wild vegetables without losing the traditional value along with scientific approaches is very essential at this stage. This can be achieved by conducting awareness and capacity building programmes to enable the people aware of using highly diversified crop plants to increase agricultural productivity, to conserve the diversified crop plants as *in*

situ germplasm for future use, to understand their service to mankind not only as a source of food, fuel, fibres etc but also for ecological services.

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