



Is traditional agroforestry system of Nagaland bountiful for indigenous and traditional crops species diversity?

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Sustaining natural resource base and augmenting productivity of tropical systems necessitate developing comprehensive understanding on the complex crop species diversity and their potential uses in traditional agroforestry systems. The present study attempts to quantify indigenous and traditional crop species diversity and extent of usage of wild edible plants in a traditional agro forestry (TAF) system using primary data from 90 households of *Konyak Naga* tribe spread across six villages of a remote district, i.e., Mon, Nagaland, North-East India. Findings reveal that the TAF system is much diversified as compared to the settled cultivation system. Apart from cereals, millets and pulses, the upland tribes grow a variety of horticultural crops on shifting cultivation (SC) land. At the aggregate level, the horticultural crops in the sampled states were observed to be much diversified and the mean diversification index value was found to be 0.79 (SID) on TAF land. The present study documented 30 indigenous and traditional crops species being cultivated and used by the *Konyak Naga* tribe. Their food system is further complemented with wild edible plants collected from fallow land and secondary forest. The existing diversity managed with traditional wisdom in the TAF system need to be preserved and disseminated in order to ensure the sustainability of the natural resource base.

Keywords: Crop diversity, Northeast India, Shifting cultivation, Upland tribes, Wild edible plants

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Shifting cultivation (SC) is one of the most age-old, pervasive and, until lately, ecologically stable forms of agroforestry. SC is a system of land use wherein trees and herbaceous field crops are consciously associated with each other at the same time¹⁻³. The origin of this sequential agroforestry system dates back to 7000 BC, i.e., the Neolithic period⁴. Though SC is such an ancient system, it is still practiced at large in the North Eastern Hill Region and some other humid and hilly regions of India. In spite of its wide spread presence, SC is perceived as multifaceted and most complex form of agriculture or agro-forestry practices in the world⁵. Because of these characteristics, there is a lack of comprehensive understanding on this type of agriculture. This age-old agroforestry system displays a preminent level of ecological rationale coupled with in-depth use of indigenous knowledge and natural resources. This also embodies management of agro-biodiversity in the form of diversified agricultural systems. Therefore, the immense challenge in recognizing the complexity

of farmers' production systems is to understand the way farmers maintain, preserve and manage biodiversity over the years.

The existing food system can be backed up and strengthened by a plethora of underutilized indigenous and traditional crops that are otherwise called as orphan crops^{6a}. These crops are considered economically, socially and environmentally more compatible. Moreover, several underutilized indigenous and traditional crops are nutri-rich and much adapted to marginal conditions. Further, these crops could be used to steer ahead the sustainable and resilient agriculture and food systems for smallholder farmers dwelling in these environments^{6b}. It has been observed that smallholder farmers and women in rural areas are negligently excluded in the case of agro-industrial food system. On the contrary, in the case of these indigenous crops, there is ample scope for inclusion of such groups of farmers as significant players into the sustainable food system. Furthermore, though there is a growing evidence base indicating the crucial role that forests and tree-based systems can play for improving food security and nutrition⁷⁻¹⁰, yet

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there are several inadequacies in our comprehensive understanding about their potential contribution in mitigating hunger and malnutrition and also unveiling the intricacies of such dynamics. There is a paucity of documentation of diversity in many North-eastern Himalayan states due to low priority, remoteness and subsequent inaccessibility to such regions¹¹. In view of this backdrop and significance of local crop diversity, the present study was undertaken to collect baseline information that is required to understand the diversity of indigenous and traditional crops and extent of usage of wild edible plants and to comprehensively understand the possible intimidation against conservation of traditional agroforestry system of Mon district in Nagaland.

Methodology

Study area

In Nagaland, with a majority (60%) of the population relying on agroforestry for livelihoods, *Jhum Kheti* (or shifting cultivation) is deeply rooted in the culture, customs and beliefs of *Nagas*^{12,13}. Prevalence of high degree of agro-biodiversity is one of the prominent characteristics of traditional agriculture practices of *Jhum Kheti*, terrace cultivation, firewood forest reserves and home gardens in Nagaland¹⁴. Moreover, the state has its own indigenous crops like *Naga Mircha*, *Naga* sweet cucumber, *Naga* garlic, *Naga* leek, etc., which have tremendous potential as a genetic resource for further development. However, these indigenous crops are yet to be exploited to their fullest potential, and therefore, it will be of immense contribution if need-based strategies are built into the programs of the state for commercial promotion of indigenous crops. It is noteworthy that the state has achieved Geographical Indication (GI) registration for Naga Chilli (GI No. 109) in 2007 and for Tree Tomato (GI No.374) in January 2012¹³. It was also observed that organic farming system is largely practiced in the state¹² wherein farmers use neither fertilizers nor other soil amendments. Therefore, over time, the soil loses its fertility, leading to low productivity, if adequate measures are not taken up for soil reclamation with organic manures/fertilizers.

The present study was conducted during 2016-17 in the northernmost Mon district of Nagaland. Of the total geographical area of the district (1,786 Sq. Km), the forest coverage is 1,207Sq. Km. (67.58%)¹⁵. The state has borders with the state of Arunachal Pradesh

to its North, Assam to its West, and the neighboring country Myanmar to its East (Fig. 1). This district is the home of the *Konyak Nagas* and they are the largest tribe among *Nagas*. *Konyaks* have the culture of getting their faces tattooed, wearing feathers and speaking the local dialect, which differs from one village to another village. This district is endowed with rich diversity in crops like rice, maize, millets, chilli and cucurbits. Though the people who dwell in this district have a rich tradition of indigenously evolved strategies for biodiversity conservation¹⁶, quantitative assessment of prevalence of such biodiversity and conservation practices is yet to be done. In fact, *Konyaks* prefer indigenous varieties over the improved ones, select elite materials to suit their needs and sustain pure varieties in their farming system¹⁷. In view of this, systematic documentation of indigenous varieties, conducting studies pertaining to nutritive value of such varieties and identification of elite types and methods of their utilization would be beneficial for the sustainable growth of this native community.

For the present study, six ethnic villages from two tribal development blocks of Mon district (26° 48' 13.81" N and 94° 58' 35.95" E) were selected. For the selection of villages, factors like the level of concentration of indigenous tribes and their dependency on SC and accessibility to study area was considered. We selected 90 households for systematic investigation on agrobiodiversity in the traditional agroforestry system. The study focused on the SC landscape mosaic (cluster of different ecosystems) like SC plot, fallow patch and surrounding forests.

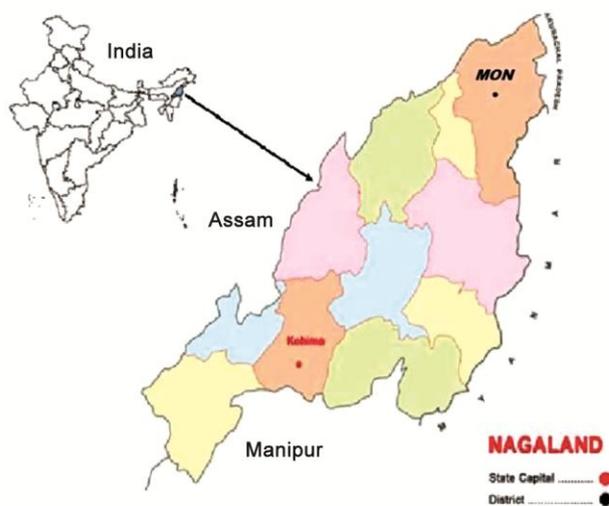


Fig. 1 — Nagaland state map showing the study area (Mon district)

The community was consulted with regard to the Free, Prior and Informed Consent agreement which contains mutually agreed-upon conditions of the research process. Also, the agreement incorporates an explanation about the possible benefits to those communities that were involved in the study and other conditions for data sharing and usage. After a satisfactory discussion with the community, the agreement was signed by their representatives. Further, for examining the prevailing diversity, a structured survey schedule coupled with a checklist of cultivated plants was used.

Crop species diversity was assessed using the Simpson Diversity Index. Simpson¹⁸ developed the diversity index for measuring crop diversity index, and the instrument is simple and easy to use, having very high level of acceptability¹⁹. The instrument is appropriate for measuring community diversity with respect to various locations and with respect to diversity difference in population. Crop diversity was calculated using following formula of SDI:

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where:

- n = number of individuals of each species
- N = total number of individuals of all species

Results

Crop diversity

The results in Table 1 reveal the most frequently recorded indigenous and traditional crops species/breeds in traditional agroforestry system. Rice and maize were reported as principal crops grown by the *Konyak Naga* of Mon, Nagaland state of North-East India.

In the SC landscape of the study area, 30 indigenous and traditional crops species were documented, of these, there were seven field crops species, 12 vegetable species, six different species of spices and condiments and five different fruit species. Of the respondents, 100% reported rice cultivation in SC land followed by maize. Finger millet and Cowpea were also reported by a significant number of respondents (Table 1). Further, we could find that among vegetable crops, the most frequently preferred vegetables were potato followed by wax gourd, taro and cucumber. In the case of fruit crops, lemon was

reported as the preferred crop, followed by banana mainly grown in SC fallow (Fig. 2).

Crop diversification index

The crop diversification index was worked out based on household-level information of tribals, and the data was triangulated during focused group discussion and the results are presented in Figure 3.

The Simpson's diversity index value for the sample area depicts maximum species diversity for vegetable

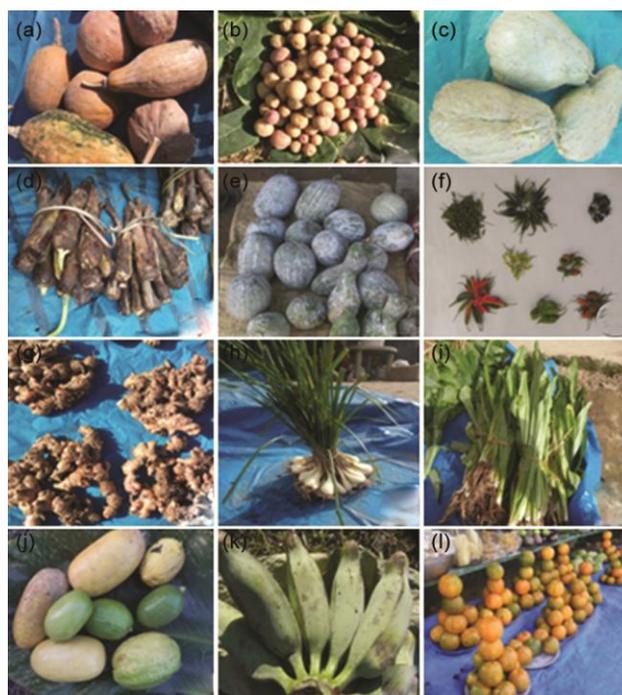


Fig. 2 — Species diversity (horticultural crops) in TAF; **a.** Pumpkin (*Cucurbita moschata*), **b.** Potato (*Solanum tuberosum*), **c.** Chayote (*Sechium edule*), **d.** Taro (*Colocasia esculenta*), **e.** Wax gourd (*Benincasa hispida*), **f.** Chilli (*Capsicum* spp.), **g.** Ginger (*Zingiber officinale*), **h.** Naga garlic (*Allium chinense*), **i.** Spiny coriander (*Eryngium foetidum*), **j.** Lemon (*Citrus limon*), **k.** Banana (*Musa* spp.), **l.** Mandarin orange (*Citrus reticulata*).

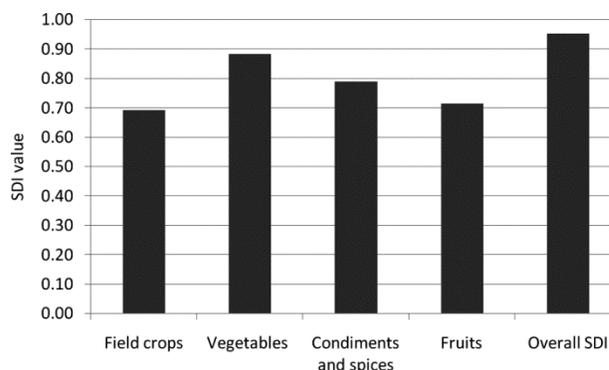


Fig. 3 — Simpson's diversity index value for the sample area

crops, followed by cereals and condiments and spices. Least species diversity index was noted in case of fruit crops and was preceded by pulses in the given ecology. As the study locale is rich in flora and fauna, several indigenous vegetables are being grown there with their culinary preferences among the SC practitioners. Similarly, chilli, lemon, pumpkin and rice have tremendous diversity in the region so were its higher diversity index.

Usage of wild edible plants

The extent of collection and usage of wild edible plants by the respondents from SC fallow/adjacent forest in the study area is presented in Figure 4.

The usage of indigenous plants and edible species recorded revealed that the use of wild edible plants, particularly bamboo shoot (a delicacy among tribals) was reported by 70% respondents followed by medicinal and aromatic plants (51%). Collection and usage of edible fruits was reported by 31% of respondents, whereas availability and usage of mushroom was found among 19% of total respondents.

Discussion

The aim of this study was to quantify the indigenous and traditional crop species diversity and extent of usage of wild edible plants in traditional

Table 1 — Percentages of the most frequently recorded traditional crop species in the sample area

Sl. No.	Crops	Frequency percentage	Local Name	Number of landrace (s)
	Field crops			
1.	Rice (<i>Oryza sativa</i>)	100	Wong	05
2.	Maize (<i>Zea mays</i>)	96.8	Wonglee	03
3.	Finger millet (<i>Eleusine coracana</i>)	25.5	Siha	02
4.	Cowpea (<i>Vigna unguiculata</i>)	23.3	Yunghe	01
5.	Sorghum (<i>Sorghum bicolor</i>)	7.7	Lah	02
6.	Chickpea (<i>Cicer arietinum</i>)	5.5		02
7.	Blackgram (<i>Vigna mungo</i>)	3.3		02
8.	Vegetables & tubers			
9.	Pumpkin (<i>Cucurbita moschata</i>)	87.7	Malong	06
10.	Potato (<i>Solanum tuberosum</i>)	87.7		04
11.	Chayote (<i>Sechium edule</i>)	82.2		02
12.	Taro (<i>Colocasia esculenta</i>)	43.3	Teang	03
13.	Wax gourd (<i>Benincasa hispida</i>)	27.7		02
14.	Cauliflower (<i>Brassica oleracea</i> var. <i>botrytis</i>)	30.0		02
15.	Mustard (<i>Brassica</i> spp.)	28.8		03
16.	Tomato (<i>Solanum lycopersicum</i>)	25.5	Hoishi	02
17.	Cucumber (<i>Cucumis sativus</i>)	23.3	Maikoh	04
18.	Bottle gourd (<i>Lagenaria siceraria</i>)	21.1	Üum	05
19.	Cabbage (<i>Brassica oleracea</i> var. <i>capitata</i>)	18.8		02
20.	Yam (<i>Dioscorea</i> spp.)	18.8	Yü Khe	06
21.	Spices & condiments			
22.	Chilli (<i>Capsicum</i> spp.)	81.1	Mak Teak	07
23.	Ginger (<i>Zingiber officinale</i>)	78.8	Teng	02
24.	Turmeric (<i>Curcuma longa</i>)	55.5		02
25.	Naga garlic (<i>Allium chinense</i>)	36.6	Atih	03
26.	Garlic (<i>Allium sativum</i>)	25.5		02
27.	Spiny coriander (<i>Eryngium foetidum</i>)	14.4	Hoi-nye	02
28.	Fruits			
29.	Banana (<i>Musa</i> spp.)	61.2	Shong Hu	05
30.	Pineapple (<i>Ananas comosus</i>)	52.2	Song Pülong	02
31.	Jackfruit (<i>Artocarpus heterophyllus</i>)	18.8	Pülong	03
32.	Mandarin orange (<i>Citrus reticulata</i>)	13	Tangpi	02
33.	Lemon (<i>Citrus limon</i>)	9	Apak Tang Pi	07

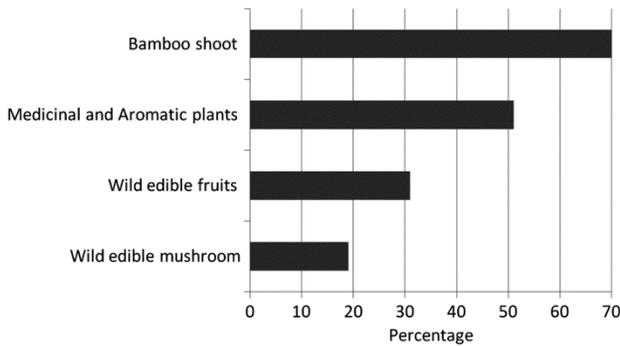


Fig. 4 — Usage of wild edible plants in sample area

agroforestry (TAF) system. Our cautious attempt could reveal that the TAF system is much diversified as compared to settled cultivation system. Including cereals, millets and pulses, the *Konyak* tribe grows a variety of horticultural crops in TAF land. At the aggregate level, the horticultural crops in the sampled states were observed to be much more diversified and the mean diversification index value was found to be 0.79 (SDI) on TAF land (Fig. 3). The present study has documented 30 indigenous and traditional crops species being cultivated and used by *Konyak Naga* tribe. Seven species of cereal crops, 18 species of vegetables, condiment and spice crops and five species of indigenous and traditional fruits were mainly found in fallow land. Among the cereal crops, we found a high density of rice and maize crops, with a number of landraces in each crop produced in that area. Apart from fresh consumption, these indigenous and traditional crops are highly preferred for preparing various fermented foods. For example, local sticky rice has special utility and is extensively used in preparation of homemade biscuits and rice beer, which are widely used in ceremonies, festivals, etc¹⁴. Further, in case of maize, it is extensively used by *Konyak Naga* for preparing soup/porridge or as an alternative to milk powder for preparing tea; the coarse granules are either cooked and eaten as rice or used as feed for pigs. Even among the vegetable species, the number of landraces in vogue reflects the species diversity. Taro is mostly used for preparation of many ethnic foods such as *anishi*, *tungkungsui*, *tungrhak*, *tunguhok*, *phalougan*, *phaloou*, etc. The leaves, petioles and damaged tubers are fed to the pigs after cooking with local edible grasses²⁰. The indigenous usage of these local landraces by these tribals in various forms, helps to conserve these species *in situ* by growth and production in TAF system.

The fallow and the secondary forest lands adjacent to the tribal dwelling area provide credence to the diversity of available food sources. This is depicted by the extent of usage of wild edible plants by *Konyak Naga* in the form of wild edible plants (WEP) by the collection from fallow land and secondary forest. Indeed, over 88% of forest is owned by private/community people in Nagaland¹³ and offers opportunity to access variety of Non-Timber Forest Products (NTFP) which is vital for local livelihood²¹. A recent study on species richness and usage of wild edible plants reported that 41 wild edible plants were used by *Konyak Naga* in Mon district of Nagaland²² endorses the biodiversity of WEP in TAF. Studies have reported 37 species of edible mushrooms from the state based on identification through traditional knowledge of the local people²³. In India, mostly in the Northeastern states, traditionally people prepare and consume different kinds of bamboo shoot-based preparations such as beverages and fermented products²⁴. These fermented bamboo shoot products are rich in bioactive nutrients and possess functional probiotic properties and are found to be a good source of vitamin B supply to the human body. It is observed that utilization of the rich agrobiodiversity and WEPs foods by the ethnic groups of Northeast India may be possibly one of the key reasons for their better nutritional and health status as compared to the rest of India. Further, these WEPs play a significant role in the sustenance of livelihood of the ethnic communities in this region. Indigenous communities' dietary diversity and food and nutritional security can be better ensured by leveraging biodiversity^{25,26} in the TAF.

Indeed, the TAF system is ingrained with traditional ecological knowledge and also increases the levels of biodiversity and diversity in management of landscape²⁷. However, subsequent transformation from a subsistence economy to a cash economy brought modern agricultural practices, which has led to the monoculture of cash crops and woodlot plantation, thereby marginalizing the tribal women in the production processes in the study area. A similar trend was also reported in the neighboring country of Bangladesh²⁸. In spite of the general opinion of SC contributing to land degradation, empirical evidence is mounting constantly that the cultivators who are practicing SC from long ago were well acquainted with their landscape in terms of soil diversity and taking up various traditional agronomic practices to minimize soil erosion, thereby conserving soil fertility of the landscape^{29,30}.

Conclusions

Our results evidently demonstrate that the SCL of the Mon, Nagaland, is a nutrition-sensitive landscape that is producing diverse sources of food while managing other ecosystem functions that are essential for environmental sustainability and human well-being. In view of this, sustaining the conservation value and ecosystem services in SCL is essential, while suggesting any land use changes for transforming it. Further, a key component of mainstreaming the biodiversity available on SC landscape is to carry out nutritional composition analysis of prioritized native edible species, i.e., both wild and cultivated, to demonstrate that these species are rich in nutrients and to use this knowledge base for effective biodiversity conservation and its sustainable use. The approach to this effect may include developing different public policies, including exploring the possibilities of providing added incentives for procurement and use of such nutrient-rich native edible species in school feeding programs. Despite many challenges, there are many advantages of using native plants for food production. Therefore, strategies in this context need to include enabling diverse agriculture entrepreneurship, preserving interspecies crop and genetic diversity to enhance crop endurance in adverse environmental conditions, reducing inputs, reducing conflicts over indigenous land management, reducing environmental conflicts and intercropping to improve land management.

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Conflicts of interest

The authors declare no conflict of interest.

Author(s) contribution

All authors have contributed equally.

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