# Traditional agroforestry of Angami Nagas of Nagaland state, India- a quantitative assessment of socio-cultural values and agrobiodiversity

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**Abstract**

Nhalie (shifting cultivation) and teizie (home garden) are the major forms of traditional agroforestry practices of Angami Nagas in Kohima district of Nagaland. They are characterized by high socio-cultural significance and prevalence of high degree of agrobiodiversity. The present study aims to assess agrobiodiversity and socio-cultural values of nhalie agroforestry of Angami Nagas in Kohima district of Nagaland, India. This study collected primary data from 60 households across five Angami villages by using methods of group discussion and participatory interview. Teizie and nhalie had higher average cultural ecosystem service values of 7.5 and 7.1, respectively. In term of economic ecosystem services, nhalie cultivation was perceived to be an important agroforestry practice with social use value (SUV) of 52.21. A total of 136 landraces of traditional crops belonging to 36 species were recorded. Two scented rice landraces (kethselha and rüluoo) and one sticky landrace (nhalenya) were reported. High overall Simpson's Diversity Index value of 0.72 revealed high level of crop species diversity in nhalie agroforestry of Angami Nagas. Rice was the most common crop with the highest genetic diversity (22 landraces) followed by pumpkin, squash, taro, cucumber and maize. Nhalie agroforestry could serve as the major reservoir of traditional crop species and contribute to the conservation of these valuable traditional crop species on-farm. Further, the existing agrobiodiversity managed with the traditional wisdom of Angami Nagas in nhalie agroforestry systems is required to be preserved and disseminated for sustainable use of bioresources.

*Keywords: Nhalie cultivation, cultural ecosystem services, landraces, conservation*

## 1. Introduction

Traditional agroforestry is a variant of conventional agroforestry ingeniously devised by indigenous people in different ecological regions of the world. These traditional farming systems have emerged over centuries of cultural and biological evolution and represent accumulated experiences of indigenous farmers interacting with the environment without access to external inputs, capital or modern scientific knowledge (Chang, 1977; Grigg, 1974; Pandey et al., 2021). Jhum (shifting cultivation) is one of the most ancient, complex, multifaceted and, until lately, ecologically stable form of agroforestry (Sharma, 1976; Darlong, 2004; Pandey et al., 2021). In this system, multipurpose traditional tree species are managed along with diverse indigenous crop varieties (Singh et al., 2014). Though jhum is an age-old agricultural system, it is still prevalent in the North-eastern hill regions and some other humid and hilly regions of India. Structural complexity, species diversity, productivity and socio-economic scopes of jhum system vary enormously in various locations. There has been no comprehensive understanding of the structure and function of this indigenous system of agriculture. There is a need for diagnosing the complexity of farmers' production system to understand the way farmers maintain, preserve and manage agrobiodiversity over the years (Pandey et al., 2021).

Terrace cultivation, jhum cultivation and home gardens are the various forms of traditional agricultural systems in Nagaland. These systems are well adapted to hilly terrains of this state, and are characterized by the prevalence of high degree of agrobiodiversity (Nakro, 2011).

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Jhum cultivation is deeply ingrained in the culture, customs and beliefs of Nagas, and 60% of the population of Nagaland relies on agroforestry for livelihoods (GON, 2015; GON, 2019). Traditional jhum cultivation involves a jhum cycle of 15-20 years of which one or two years for cultivation followed by a period of fallow regeneration for 13-18 years (Rathore et al., 2010). The Angami Nagas subsist primarily by cultivating the hill slopes surrounding their village (Changkija, 2014). Alder-based jhum is one of the major forms of traditional agroforestry systems of the Angami Nagas (Rathore et al., 2010; Nakro, 2011). Construction of terraces is not feasible in many parts of this mountainous state (NEPED and IIRR, 1999). Therefore, the replacement of jhum practices with permanent terrace cultivation is not possible in many places, and jhum system persists to be the major source of food and subsistence needs of poor marginalized farmers. Majority of traditional varieties of crops are grown chiefly in jhum fields. Underutilized indigenous crops are economically, socially and environmentally more compatible, and are nutri-rich and much adapted to marginal conditions (Pandey et al., 2021). Indigenous landraces of various crops harbour novel genes for future crop breeding programmes (Patra et al., 2016). Farmers grow indigenous landraces of various crops according to their preferences with respect to colour, taste, aroma and cooking quality. Angami food system is supplemented with diverse major and minor dishes collected from farm and wild ecosystems (Singh and Teron, 2017).

In recent times, agricultural practices have been intensified for increasing crop yields to meet the demand of increasing human population. Such intensification makes significant changes in the traditional agricultural practices. For example, jhum cycle (traditionally 15-20 years) has been reduced to 4-7 years; folk varieties of crops have been gradually replaced with high yielding varieties (HYV); and traditional jhum systems gradually lose their resilience power. Shorter jhum cycle cannot give sufficient time for fallow regeneration. These changes cause rapid deterioration of soil quality, further affecting crop yields and loss of valuable plant genetic resources (NEPED and IIRR, 1999; Nakro, 2011; Changkija, 2014). Nakro (2011) reported diversified forms of traditional agriculture practices and agrobiodiversity in Nagaland. Mezhü et al. (2017) studied the genetic diversity of locally cultivated taro from 11 districts of Nagaland including 11 cultivars from Kohima district. Thirty indigenous crop species cultivated by Konyak Naga were reported from Mon district of Nagaland (Pandey et al., 2021). Twenty-nine upland rice landraces were reported from Kohima district of Nagaland (Roy et al., 2014; Toshimenla et al., 2016; Vanlalsanga et al., 2019). Some studies reported diversity of crop species and wild edible plants (WEP) managed in Angami homegardens (Singh and Teron, 2015; Singh and Teron, 2017). Pandey et al. (2020) studied the socio-cultural and economic importance of jhum cultivation in Mon district of Nagaland. Review of various reports revealed scant information on agrobiodiversity and cultural values of traditional agroforestry systems of Angami Nagas of Nagaland. The present study aims to assess agrobiodiversity and socio-cultural values of nhalie agroforestry of Angami Nagas in Kohima district of Nagaland. This study would be helpful for policy makers to address the present issues of jhum cultivation in the state. Further, information generated from this study will be of immense contribution to conservation of agrobiodiversity and commercial promotion of underutilized indigenous crops in the state.

## 2. Materials and methods

### *2.1. The study area and the people*

Nagaland represents one of the eight states in North-eastern region of India. The Kohima district (25°11'N – 26°N and 93°20'E – 94°55'E) of the state with its headquarter at Kohima is located at 1450 m above sea level covering a geographical area of 4041 sq km. The region is considered as the homeland of the Angami Naga, one of the 14 Naga tribes of the state (Basic facts Nagaland, 2018). There are more than 60 Angami villages in Kohima, and each village consists of 60-900 houses (Punyu, 2010). This district harbours a rich diversity of indigenous crops such as rice, maize, millets, taro, squash and cucurbits. Angami Nagas have a rich tradition of indigenously evolved strategies for biodiversity conservation (Godbole and Sarnaik, 2009). They practice animistic form of religion which includes belief on multiple deities. Under the influence of missionary, majority of the Angamis have embraced Christianity; today their animistic religion remains confined to only a few Angami groups. Agriculture

is the main occupation and rice is their staple food. Wet terrace and jhum cultivation are the major forms of agricultural systems.

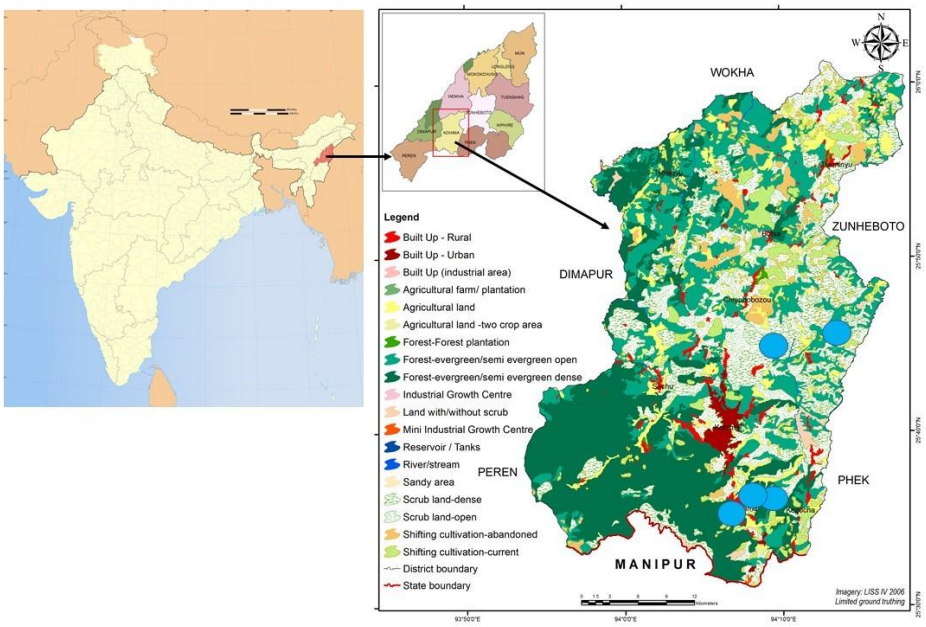


Figure 01. Land use map of Kohima district showing the study sites (blue circles) (Source: Nagaland GIS and Remote Sensing Centre Planning and Co-ordination Department, Government of Nagaland)

*2.2. Collection of data*

The present study was conducted in five Angami villages, namely Rusoma, Dihoma, Mima, Mitelephe and Kigwema in Kohima district of Nagaland from 2019 to 2021 (Figure 01). Permission for field study and consents were obtained from the Chairmen of village councils and key informants, respectively. Selection of villages in this study was based on some important parameters including prevalence of jhum cultivation in the village, level of dependency of rural Angamis on jhum and accessibility to study area (Pandey et al., 2021). Fifteen elderly knowledgeable farmers who had experiences of more than 10 years in jhum cultivation were selected from each of the five Angami villages for group discussions on traditional knowledge of plant propagation, management of each plant species cultivated in agroforestry, food habit, socio-cultural and economic importance of various crops, yields, size of agricultural plots, traditional knowledge of post-harvest techniques, processing and storage of crops. A checklist of plants available in Angami agroforestry fields was prepared through group discussions and personal observations in the field (Vogl et al., 2004). Free listing interviews of 30 elderly women were conducted to document uses and the cultural importance of WEPs (Guest et al., 2006).

*2.3. Social research methods*

Sixty landowners who had extensive knowledge about traditional land use systems, were interviewed. To assess the importance of provisional and cultural ecosystem services of traditional agroforestry systems, farmers were asked to rank the cultural, commercial and subsistence value of agroforestry systems on a scale of 1–10 by participatory interview (Salmon, 2007). Socio-cultural values comprised cultural, commercial and subsistence attributes and ranged from 1 (least important) to 10 (most important) (Pietersen et al., 2018). The average score for each agroforestry system was calculated.

Farmers were asked to rank 33 woody plant species that provided the economic ecosystem services including crafting materials, food, medicine, construction materials, shadow and fencing trees, fodder, firewood, ornamental and reforestation species (De Groot and van der Meer, 2010). Further, farmers were asked which agroforestry system that each product was collected from and if the product was used mainly for commercial or subsistence purposes to determine the social use value (SUV) of the traditional

agroforestry systems (Holzman, 2012). The SUV was calculated based on the number of times a plant species for a specific use was collected from a certain agroforestry system, and as a percentage of the total number of all registered plant individuals perceived to be important for the economic ecosystem services (Pietersen et al., 2018). A total of 113 species perceived to be important for the economic ecosystem services were registered.

$$SUV = \frac{\sum n}{N} \times 100$$

$$Species\% = \frac{n}{N} \times 100$$

Where, n is the number of species used for one specific economic ecosystem service and N is the total number of species registered (113).

*2.4.Analysis of crop species diversity*

Twelve households were selected from each of the five Angami villages, and the analysis of crop species diversity was carried out on the respective household's jhum field. A single household and its jhum field were considered as a sample for species diversity analysis. For the jhum field assessment, a square quadrant of 20m × 20m each was laid in the sampled household's jhum field and accounted for vegetation of agricultural species (Pandey et al., 2021). Participatory approach was adopted to ensure that the sample plots could cover both perennial woody species and annual crop species in the jhum fields (Pandey et al., 2021). Plant species growing in the sample plots were enumerated, and the number of individuals of each species was recorded.

Crop species diversity was measured using the Simpson's Diversity Index (SDI) (Simpson, 1949). Crop diversity was calculated using the following formula:

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

Where, n is the number of individuals of each species and N is the total number of individuals of all species. The crop diversification index was worked out based on household-level information of tribals (Pandey et al., 2021).

## 3. Results

*3.1. Angami agroforestry*

Angami agroforestry system was categorised into four distinct forms based on the associated local management practices. They are (i) nhalie (jhum), (ii) teizie/ozhwe/avie (home garden), (iii) tekhu (terrace field) and (iv) luzhü (plantation of different fruit trees in combination with annual crops). Each of these systems has its distinctive structure, functions and socio-cultural significance. These systems persist as means of basic economic and subsistence needs of the rural people. Further, management of these systems reflects the inter dependency and cultural bonding among the rural Angamis.

*3.2. Socio-cultural values of traditional agroforestry system*

This study evaluated the socio-cultural value for identity, commercial and subsistence of the major forms of Angami agroforestry systems. The socio-cultural values ranged from 4 to 8.4 (Table 01). Mean assigned value of cultural ecosystem services indicates the relative importance of traditional agroforestry systems. Results of this study revealed that nhalie and teizie had the highest commercial value of 7.6 each, whereas the lowest commercial value of 4 was found in tekhu. Teizie had the highest subsistence value of 8.4 followed by tekhu (7.3), nhalie (6.6) and luzhü (4.7), whereas the highest cultural identity value (8.2) was found in tekhu. The highest average value of cultural ecosystem services was found in teizie (7.5) followed by nhalie (7.1), tekhu (6.5) and luzhü (5.4). Therefore, teizie was perceived to be the most important agroforestry system. However, no agroforestry system can cope with all the needs of a farmer. As a result, farmers subsist on all forms of traditional agroforestry.

This study documented 33 woody species from traditional agroforestry. Results of this study revealed that nhalie and teizie could provide all the enumerated economic ecosystem services (Table

02). Teizie had the highest SUV (67.26), whereas the lowest SUV was found in luzhü (20.32). Farmers used the highest number of woody species belonging to different economic ecosystem services from teizie (76) followed by nhalie fields (59), tekhu fields (56) and luzhü (23).

Table 01. Assigned values of cultural ecosystem services of Angami agroforestry systems

| Local management | Agroforestry systems | Cultural Identity value | Commercial value | Subsistence value | Mean value |
|---|---|---|---|---|---|
| Nhalie | Slash and burn | 7.1 | 7.6 | 6.6 | 7.1 |
| Teizie | Home garden | 6.4 | 7.6 | 8.4 | 7.5 |
| Tekhu | Terrace field | 8.2 | 4 | 7.3 | 6.5 |
| Luzhü | Plantation of fruit trees with combination of crops | 5.5 | 5.8 | 4.7 | 5.4 |

Table 02**.** Potential economic ecosystem services of woody species in nhalie, teizie, tekhu and luzhü in Kohima district of Nagaland, India

| Use categories | Nhalie | | Teizie | | Tekhu | | Luzhü | |
|---|---|---|---|---|---|---|---|---|
| | Species % | No. of species used | Species % | No. of species used | Species % | No of species used | Species % | No. of species used |
| Crafting material | 7.08 | 8 | 8.85 | 10 | 6.19 | 7 | 0.88 | 1 |
| Construction | 8.85 | 10 | 10.62 | 12 | 7.08 | 8 | 0.88 | 1 |
| Food | 7.08 | 8 | 14.16 | 16 | 8.85 | 10 | 6.19 | 7 |
| Firewood | 14.16 | 16 | 17.70 | 20 | 12.39 | 14 | 5.31 | 6 |
| Fodder | 1.77 | 2 | 1.77 | 2 | 1.77 | 2 | 0 | 0 |
| Medicine | 3.54 | 4 | 4.42 | 5 | 5.31 | 6 | 4.42 | 5 |
| Ornamental | 0.88 | 1 | 0.88 | 1 | 0.88 | 1 | 0.88 | 1 |
| Reforestation | 7.08 | 8 | 6.19 | 7 | 0 | 0 | 0.88 | 1 |
| Shadow and fencing | 1.77 | 2 | 2.65 | 3 | 1.77 | 2 | 0.88 | 1 |
| Total | 52.21 | 59 | 67.26 | 76 | 45.13 | 51 | 20.32 | 23 |


Figure 02. Agrobiodiversity in jhum agroforestry of Angami Nagas (a) squash, (b) wax gourd, (c) ginger, (d) lablab beans, (e) bottle gourd, (f) *Allium chinense*, (g) *Allium sativum*, (h) *Allium chinense*, (i) pumpkin, (j) taro, (k) sticky maize, (l) non-sticky maize

*3.3.Crop diversity*

This study aimed to evaluate agrobiodiversity in nhalie agroforestry and documented 36 indigenous crop species belonging to 28 genera under 12 families. Traditional crop species cultivated in nhalie agroforestry were categorized into four crop types (Pandey et al., 2019) (Supplementary table 01). For example- field crops (12 species), vegetables and tubers (16), spices and condiments (7) and fruits (2). Cucurbitaceae represented the highest number of species (8) followed by Leguminosae (7), Poaceae (5), Solanaceae (4), Amaryllidaceae (3), Lamiaceae and Malvaceae (2 each) and Asteraceae, Araceae, Brassicaceae, Phyllanthaceae, Moraceae (1 each). A total of 136 landraces belonging to 36 crop species were recorded. This study revealed high level of genetic diversity in diverse indigenous crop species such as rice, maize, pumpkin, cucumber, taro, squash, brinjal, cowpea, lablab beans, beans, bottle gourd and wax gourd (Figure 02). Rice represented the highest number of landraces (22), whereas *Sorghum* sp. and sunflower had the least number of landrace (1 each) (Figure 03). Out of 22 upland indigenous rice landraces reported, nine landraces could not be found in the study area (Supplementary table 01). Farmers reported two scented rice landraces (kethselha and rüluoo) and one sticky landrace (nhalenya). Traditionally nhalie rice is broadly classified into two groups based on the year of nhalie cultivation, namely as pelulha (cultivated in first year nhalie) and thekelha (cultivated in second year nhalie). Twenty-one rice landraces were under pelulha, while one landrace was thekelha. The present study documented four species of pumpkin (*Cucurbita moschata*, *Cucurbita maxima*, *Cucurbita pepo* and *Cucurbita ficifolia*) of which *Cucurbita ficifolia* was reported from Kohima district of Nagaland for the first time.

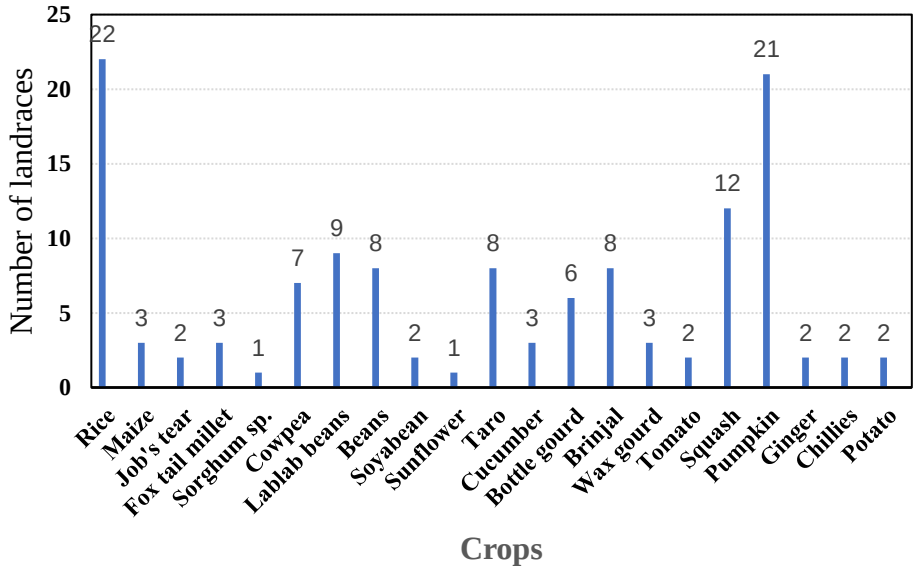


Figure 03. Distribution of landraces of indigenous crop species cultivated in jhum agroforestry

Rice was the principal crop grown by all respondents in agroforestry fields followed by maize (Figure 04). Among field crops beans, lablab beans, soyabeans and cowpea were also grown by a good number of respondents, whereas sunflower was the least cultivated species (8%). Further, among vegetable crops squash, pumpkin, taro, cucumber and tomato were the most frequently preferred vegetables. Significant number of respondents reported the use of chillies, onion, garlic and ginger as spices and condiments. Indian gooseberry was reported to be the most cultivated fruit tree.

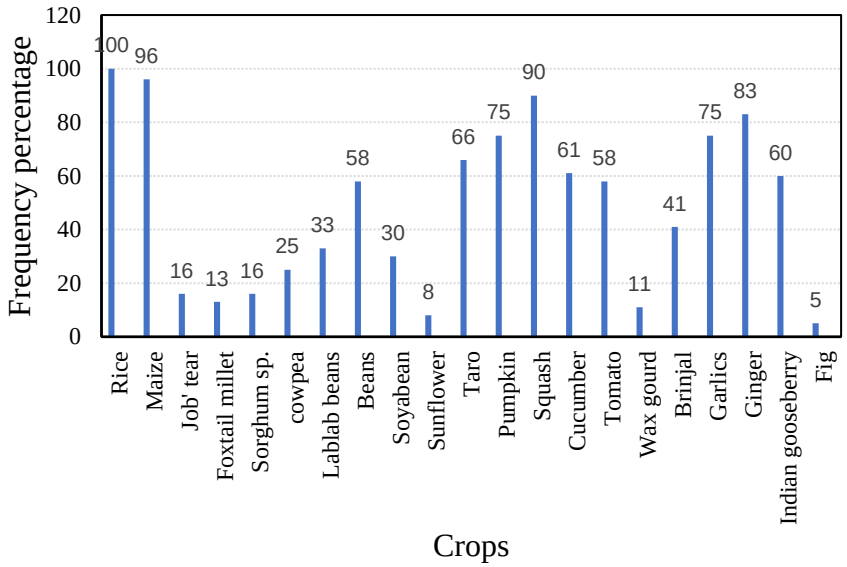


Figure 04. Percentage of the most frequently cultivated traditional crop species in the study area

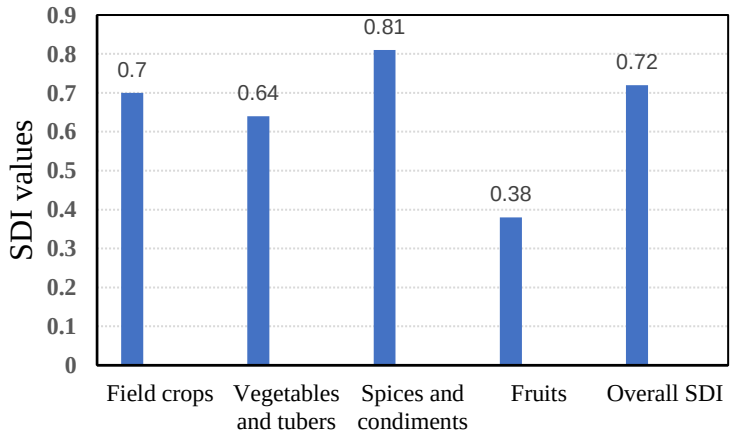


Figure 05. Simpson's diversity index value for the sample area

*3.4.Crop diversification index*

The present study revealed high diversity of crop species in nhalie agroforestry from the sampled area. Maximum species diversity was observed among spices and condiments followed by cereals, vegetables and tubers (Figure 05). Fruit crops had the least species diversity index. Farmers cultivate several indigenous and traditional crops chiefly in nhalie agroforestry for their culinary preference and socio-economic significance. Overall SDI value was found to be 0.72 in the sample area.

*3.5.Wild harvested plants*

Rural Angamis collect plethora of wild edible species from nhalie fallow and wild habitats which are located at road sides, secondary forests and other natural forest areas for food, medicine and animal feed. Wild plants contributed 61% of the total products used by Angami Nagas. Figure 06 presents the extent of collection and usage of WEPs by the respondents from nhalie fallow and wild ecosystems closer to residential areas. All respondents reported the use of WEPs as foods. Usage of WEPs as animal feeds was reported by 66% of respondents, whereas usage of medicine was found among 58% of respondents. Some respondents (41%) used WEPs for other utilities, such as firewood and fencing.

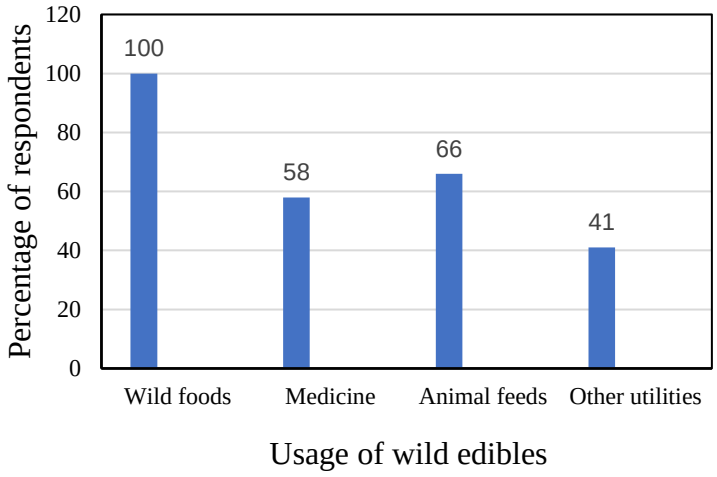


Figure 06. Usage of wild edible plants in the study area

## 4. Discussion

### *4.1. Continuation of traditional agroforestry*

The Angami Nagas classify land into two types based on the nature of use- land for cultivation (nhalie, tekhu, teizie and luzhü) and residential land (Changkija, 2014). Teizie which had the highest mean value of cultural ecosystem services (7.5) was perceived to be the most important agroforestry system compared to nhalie, tekhu and luzhü. Higher social use value of 67.26 in teizie revealed the higher dependency of poor farmers on home gardens for their livelihood and food security. Angami Nagas maintain teizie closer to their houses (Godbole, 1998) and manage economically important crops (maize and sugarcane), vegetable crops (cabbage, broccoli, mustard, taro, squash, brinjal, tomato and cucumber), horticultural crops (fruit trees), spices and other wild edible species of frequent use. Teizie has significant role in providing food supplementation throughout the year. Further, teizie provides major source of animal feeds and firewood. However, teizie has lesser cultural value of 6.4 than that of nhalie and tekhu. Angamis have been practicing nhalie and tekhu for centuries (Nakro, 2011). Distinctive structure, functions and socio-economic significance of these traditional upland agricultural systems have been evolved, and Angamis obtain their subsistence needs from these upland farming systems. Angami Nagas are well known for their skills in terrace constructions even on highly steep sides of mountains where sufficient amount of rain is received for irrigation (Nakro, 2011). One study revealed that the age of terraces was as old as the age of village since these terraces had been constructed at the time of establishment of the village and subsequently nhalie land of the village was also established (Nakro, 2011). Higher cultural identity value of tekhu (8.2) and nhalie (7.1) revealed the cultural importance of these traditional upland agricultural systems in the life of rural Angamis. Prevalence of tekhu in Angami villages mainly depends on the feasibility of terrace constructions in the huge mountain terrains and sufficient availability of water for irrigation (Nakro, 2011), whereas nhalie is common to all Nagas. For example- tekhu is rare in Dihoma village which receives less amount of rainfall as compared to other villages. In those villages where tekhu is not possible, farmers hardly have alternative means of livelihood other than management of nhalie and teizie, and thus they mainly rely on nhalie and teizie for their subsistence needs. Many studies reported the adverse effects of recent shortening of nhalie cycle to 4-7 years including soil erosion and degradation of soil quality which cause rapid decline in crop yields (Choudhury and Sundriyal, 2003; Nakro, 2011; Rajkhowa et al., 2017).

Initiatives from Government of Nagaland for the introduction of alternative settled farming to replace jhum cultivation were not successful to large extent (Choudhury and Sundriyal, 2003). This can be attributed to reluctance of many farmers to adopt such newly introduced agriculture because of its high cost of production, inexperience in new farming, failure to convince the reliability of new farming, lesser cultural significance and emphasis on monoculture or less crop diversity. At the present time, though jhum cultivation is widely discouraged due to its adverse ecological impact, this system persists

as a major source of subsistence for marginalized poor farmers. Higher average value of cultural ecosystem services (7.1) and economic ecosystem services (SUV = 52.21) in nhalie cultivation showed the intrinsic value of this system which was ingrained so deeply in the life of Angamis. Therefore, it would be difficult to eliminate this system from the life of Angamis. One study reported the persistence of jhum cultivation in Mon district of Nagaland since it was part of the culture and tradition of indigenous people, a means of livelihood, and there was lacking of any worthwhile alternative (Pandey et al., 2020) which was consistent with the results of this study. As a result, complete elimination of jhum cultivation from Nagaland state without any provision of alternative source of livelihood for marginalized farmers may not be possible (Rajkhowa et al., 2017). Rather, farmers may be encouraged to introduce agroforestry in jhum fields and manage suitable local tree species that can rejuvenate soil fertility faster and prevent soil erosion, and thus transform jhum into a sustainable upland agricultural system which can continue to contribute its valuable services to achieve sustainable development goals.

*4.2. Agrobiodiversity*

The present study attempted to quantify the diversity of indigenous traditional crop species managed in nhalie agroforestry of Angami Nagas in Kohima district of Nagaland, India. Similar studies on agrobiodiversity in jhum cultivation have been earlier reported by various workers (Alam and Mohiuddin, 2009; Pradheep et al., 2014; Pandey et al., 2019). Forty crop species including 20 rice cultivars cultivated in jhum fields were reported from Chittagong hill tracts in Bangladesh (Alam and Mohiuddin, 2009). Collection of 138 accessions of agri-horticultural crops belonging to 42 species from Mon district of Nagaland signified rich variability in major field crops, such as rice, maize and foxtail millet (Pradheep et al., 2014). Quantitative assessment of crop species diversity in shifting cultivation was carried out in six states of Northeast India and reported 12 field crops, 25 vegetable crop and 22 crop species of fruit, condiments and spices (Pandey et al., 2019). Results of this study revealed that Kohima district of Nagaland had richer crop species (36) than that reported from other parts of North-eastern regions of India- Mon district of Nagaland (30 species), Churachandpur district of Manipur (32), Saiha in Mizoram (30) and Dhalai district of Tripura (19) (Pandey et al., 2019). One study documented 39 and 37 crop species from West Garo Hills district of Meghalaya and Upper Subansiri district of Arunachal Pradesh, respectively (Pandey et al., 2019). At the aggregate level, cereal and pulse crops in the sampled areas was observed to be more diverse and the mean diversification index value was found to be 0.63 on nhalie agroforestry land (Fig. 5). Species richness of vegetables and spices and condiments (23 species) recorded in this study was higher than that reported from Mon district of Nagaland (18 species) (Pandey et al., 2021). Fruit species richness (2 species) in this study was less than that of earlier similar studies (Pandey et al., 2019; Pandey et al., 2021). Overall SDI value of 0.72 was less than that reported from Mon District of Nagaland (Pandey et al., 2021). This discrepancy in the species richness in jhum cultivation landscapes in various parts of Northeast India may be attributed to two reasons- (i) cultivators' varied preference factors including colour, palatability, aroma, flavour and socio-economic significance of crops and (ii) varied adaptability of crops to varied physical factors including soil type, altitude, temperature and availability of water in various jhum landscapes.

Rice forms the most common crop possessing higher genetic diversity with 22 landraces of which 21 landraces belong to non-sticky type which is preferred for daily consumption followed by maize, squash, pumpkin, taro and cucumber. Sticky types of rice are used in preparation of rice biscuits and rice beer, and are also used in ceremonies or festivals (Pandey et al., 2021). However, farmers grow these landraces in lesser quantity since they are poor yielding (Nakro, 2011). In Rusoma village scented black rice was reported to be used in making tea. In this study, two scented rice landraces (kethselha and rüluoo) were reported from Kohima district, while two other types of scented rice (gam and thaling) were reported from Mon district of Nagaland (Pradheep et al., 2014). Both sticky and non-sticky rice consist of both scented and non-scented types of rice. This study reported two types of maize- sticky (Kemengashüko) and non-sticky (kemephroshüko). Traditionally, Konyak Nagas roast mature kernels and pound them in traditional wooden mortar and pestle to fine powder which is either used 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 pig feed (Pandey et al., 2021). Whereas, Angami Nagas use maize mainly as food and pig feeds. Corms and leaves of taro are mostly used for the preparation of an ethnic food of Angami known as tathu and are also used to cook with meat (Singh and Teron, 2017). Leaves, petioles and corms of taro are cooked with local edible grasses for feeding the pigs (Bapat, 2013). Of four species of pumpkin recorded in this study, *Cucurbita ficifolia* was used as pig feed but not as human food. A good number of WEPs constitute vital ingredients of different traditional dishes of Angami food system (Singh and Teron, 2017). The extent of usage of WEPs shows that jhum fallow and secondary forests rich in WEPs will augment the diversity of available food resources of Angami Nagas. Maintenance of biodiversity is key for the sustainable production of food and other agricultural products which will ensure food, nutritional and livelihood security for the tribals of Northeast India (Pandey et at., 2019).

*4.3. Agroforestry for food and livelihood security*

This study revealed higher diversity of traditional crop species in nhalie agroforestry. Rural Angamis hardly procured foods from other places since there was lack of market facilities and public transportation system in village areas. Therefore, rural Angamis mainly relied on agroforestry products and wild edibles for their food. There had been simple form of intervillage buying and selling and exchange of farm products. Many poor rural people who do not get permanent vender seats in major markets in the town directly sell their farm products and other wild edible plants at the price of retailers at footpath in the town areas or at the side of highways. It had also been observed that farmers brought their farm products to town areas and sold at wholesale rate to the retailers. Interestingly, agroforestry products are sold at the price higher than that of vegetables or fruits brought from outside the state. Though the price of agroforestry products is higher, people prefer to buy these products for the obvious reasons of organic and palatability. Further, firewood harvested from the thinning and pollarding of fallow trees in nhalie fields are sold for generating additional cash income. Thus, selling of various agroforestry products and WEPs serves as an important means of earning cash income for improving the economy of poor farmers.

*4.4. Motives for maintenance of high agrobiodiversity of local landraces*

Angami Nagas avert the risk of crop failure by cultivating many economic species (in teizie) and diverse heirloom folk varieties of crops (in nhalie fields). This ensures yield in the long term, maximum returns with low input of technology and resources and promotes diverse options in diet (Harwood, 1979). Indigenous upland rice landraces cultivated in jhum agroforestry in Nagaland are poor yielding (Roy et al., 2014). However, these landraces hoard many valuable traits, such as good taste, flavour, aroma, cold tolerance and drought stress tolerance important for crop improvement programmes (Tirkey et al., 2013). Farmers prefer indigenous varieties over the improved ones, select elite materials to suit their needs and sustain pure varieties in their farming system (Pradheep et al., 2014). Further, no HYV suitable for rainfed jhum ecosystems is available. Therefore, frequency of use of local seeds is significantly higher among the jhumias (shifting cultivators) (Lalengzama, 2019). Many indigenous and traditional crop species have socio-cultural significances. For example- sticky rice is used for brewing rice beer which is used in many rituals, celebration and festivals; hard and dried pericarp of bottle gourd is beautifully crafted to form traditional container/cup for storing rice beer, for carrying water and drinking water; cylinder made from dried pericarp of *Luffa cylindrica* and pumpkin are used for storing seeds (Changkija, 2014); fibre obtained from dried pericarp of *Luffa cylindrica* is used for cleaning cooking and eating utensils. Hence, despite introducing modern agriculture and growing pressure to discontinue cultivation of traditional varieties, farmers persist in growing their heirloom traditional varieties chiefly in nhalie fields to fulfil their socio-cultural needs. This may contribute to the conservation of these valuable traditional crop species on-farm. Women play a major role in selection of seeds and conservation of germplasm of local cultivars. They involve in all farm related works including carrying farm products and WEPs to nearby market. Rice grains are exposed to the sun by spreading them in thin layer on a large traditional bamboo mat before they are stored in traditional granary made of bamboo mat. Panicles of foxtail millet, ears of maize and bulbs of garlics or spring onion, dried fruits of brinjal (often longitudinally cut into four splits), chilli and cucurbits are safely kept for next year's sowing by hanging them on the veranda or on rafter inside the home near smoke kiln to

ward off pests (Pradheep et al., 2014). Traditional knowledge of Angami Nagas for the management of biodiversity is required to be preserved in order to ensure the conservation of the valuable genetic resources of traditional crop species.

### *4.5. Influence of modern crops on Angami agroforestry*

Mixed cropping is the pattern of cropping in Angami agroforestry. Many farmers perceived that such cropping patterns can enhance productivity. In recent times, there have been changes in traditional land use systems towards permanent farming like horticulture and rubber plantation, replacement of indigenous varieties with modern crops/HYV and homogenization of agricultural production systems (Dikshit and Dikshit, 2014). Introduction of modern crops decreases agrobiodiversity in traditional agroforestry and alters the structure and functions of traditional agroforestry systems into monoculture which narrows down ecosystem services, and thus eroding valuable plant genetic resources from the farmers' fields.

## 5. Conclusions

Teizie and nhalie had higher average cultural ecosystem service values of 7.5 and 7.1, respectively. In term of economic ecosystem services, nhalie cultivation was perceived to be an important agroforestry practice with SUV of 52.21. A total of 136 landraces of traditional crops belonging to 36 species were documented. Two scented rice landraces (kethselha and rüluoo) and one sticky landrace (nhalenya) were reported. Two types of maize- sticky (kemengashüko) and non-sticky (kemephroshüko) were recorded. Rice was the most common crop with higher genetic diversity (22 landraces) followed by pumpkin, squash, taro, maize and cucumber. Angami food system was also complemented by good number of WEPs collected from nhalie fallow and wild ecosystems. High level of genetic diversity in traditional crop species could be the potential source of novel genes for future crop improvement programmes. Though traditional crops have been gradually replaced with HYVs, farmers persist to grow their heirloom traditional varieties chiefly in nhalie fields for the obvious reasons of palatability and socio-cultural significances. This may contribute to the conservation of these valuable traditional crop species on-farm. As a result, nhalie agroforestry of Angami Nagas could serve as a major repository of indigenous crop species. Indigenous traditional crop varieties recorded in this study can be further characterized in the future research for their use in crop breeding programmes. Further, the traditional wisdom of Angami Nagas for the management of agrobiodiversity in nhalie agroforestry is required to be preserved and disseminated for sustainable use of bioresources. Despite adverse ecological impact and wide discouragement of jhum cultivation, complete elimination of this practice from Nagaland state without any provision of alternative source of livelihood for marginalized farmers may not be possible. Farmers may be encouraged to introduce agroforestry and manage suitable local tree species in jhum fields for the transformation of jhum into a sustainable upland farming system.

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