Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 11(X), 2023:
http://dx.doi.org/10.7770/10.7770/safer-V11N1-art2318

Traditional agroforestry for food security and agrobiodiversity- The Angami Naga Nhalie-Teizie binary system in Nagaland state of India.

Agrosilvicultura tradicional para la seguridad alimentaria y la agrobiodiversidad: el sistema binario Angami Naga Nhalie-Teizie en el estado de Nagaland, India.

Akoijam Basanta Singh* and Robindra Teron

Department of Life Science & Bioinformatics, Assam University-Diphu Campus, Diphu, Karbi Anglong 782 462, Assam, India.

*Corresponding author's E-mail: basanta57@gmail.com

ABSTRACT

Traditional agroforestry practice of Angami Nagas is the integrated system of cultivating multipurpose local tree species with traditional crops varieties. Nhalie (slash and burn) and Teizie (home garden) are the two major forms of traditional agroforestry which are the primary sources of food, medicine, firewood, fodder, cultural needs, livelihoods and other utilities of equal importance. The present study, which was conducted from, March 2016 to November 2019, aims to investigate the contribution of traditional agroforestry to food security among the Angami Nagas of Kohima district, Nagaland. Data collection methods included group discussion, semi-structured interview and field observations. Angami agroforestry is the main repository of agrobiodiversity. Agrobiodiversity plays important role in food security of the Angami Nagas. Agrobiodiversity avails of continuous accessibility of diverse foods all the year round. This study documented 32 species under 8 types of crops cultivated in Nhalie and 71 species of food plants from Teizie (homegarden). Nhalie has the potential to augment coproduction of foods and firewood to meet the increasing needs of food and energy security without negative consequences on environment. Pretty good number of wild edibles and conventional crops growing in home gardens contributes towards supplementing food during off season. Well-designed Angami granary and traditional techniques of preservation help to ensure food security by reducing unwanted post-harvest damages. Angami agroforestry not only enhances food and energy security but also infers as a tool for conservation of agrobiodiversity and sustainable development.

Keywords: Alder, oak, slash and burn, homegarden, sustainable development, conservation.

RESUMEN

La práctica agroforestal tradicional de Angami Nagas es el sistema integrado de cultivo de especies de árboles locales multipropósito con variedades de cultivos tradicionales. Nhalie (tala y quema) y Teizie (huerto doméstico) son las dos formas principales de agrosilvicultura tradicional que son las principales fuentes de alimentos, medicinas, leña, forraje, necesidades culturales, medios de subsistencia y otros servicios públicos de igual importancia. El presente estudio, que se llevó a cabo entre marzo de 2016 y noviembre de 2019, tiene como objetivo investigar la contribución de la agrosilvicultura tradicional a la seguridad alimentaria entre los angami nagas del distrito de Kohima, Nagaland. Los métodos de recolección de datos incluyeron discusiones grupales, entrevistas semiestructuradas y observaciones de campo. La agrosilvicultura de Angami es el principal depósito de agrobiodiversidad. La agrobiodiversidad juega un papel importante en la seguridad alimentaria de los Angami Nagas. La agrobiodiversidad se beneficia de la accesibilidad continua de diversos alimentos durante todo el año. Este estudio documentó 32 especies bajo 8 tipos de cultivos cultivados en Nhalie y 71 especies de plantas alimenticias de Teizie (huerto familiar). Nhalie tiene el potencial de aumentar la coproducción de alimentos y leña para satisfacer las crecientes necesidades de seguridad alimentaria y energética sin consecuencias negativas para el medio ambiente. Un buen número de comestibles silvestres y cultivos convencionales que crecen en los huertos familiares contribuye a complementar los alimentos durante la temporada baja. El granero Angami bien diseñado y las técnicas tradicionales de conservación ayudan a garantizar la seguridad alimentaria al reducir los daños no deseados posteriores a la cosecha. La agrosilvicultura de Angami no solo mejora la seguridad alimentaria y energética, sino que también se infiere como una herramienta para la conservación de la agrobiodiversidad y el desarrollo sostenible.

Palabras clave: aliso, roble, tala y quema, huerto familiar, desarrollo sostenible, conservación.

INTRODUCTION

Agroforestry is a sustainable and multifunctional land management system characterized by purposeful growing or deliberate retention of trees with agricultural crops and/or livestock on the same piece of land (Quandt et al. 2018). Multiple implications of these systems include improvement in food production, economy, livelihoods (Jemal et al. 2018), poverty alleviation (Shukla et al. 2018) and biodiversity conservation (Huang et al. 2002). Multipurpose tree species cultivated in such land use systems not only supply timber and firewood but also helps to maintain soil fertility and reduce soil erosion (Hoosbeek et al. 2018, Kuyah et al. 2019). Traditional agroforestry is a variant of agroforestry ingeniously devised by indigenous people in different ecological regions of the world, for example agrisilviculture, silvopastoral, agrosilvopastoral and homegarden. Agroforestry has the potential to ensure food and energy security with resilience of ecological imbalance (Sharma et al. 2016). Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets dietary needs and food preferences for active productive and healthy life (World Food Summit 1996). There is recent global interest to investigate the potential roles of agroforestry practices to meet the needs of food and nutritional security among the smallholder farmers

(Kahane et al. 2013, Abdulhamid et al. 2017, Waldron et al. 2017, Whitney et al. 2018). Agroforestry supports food and nutritional security through the direct provision of food, by raising farmers' incomes and providing fuel for cooking, and through various ecosystem services (Dawson et al. 2013).

Nagaland is a mountainous state in the North Eastern frontier of India. More than 70% of the population of the state is dependent on agriculture and other farm-based activities (Kehie et al. 2017). Jhum (slash and burn) and terrace cultivation are the two major forms of agricultural practices in Nagaland. However, terrace cultivation is concentrated mainly in regions with high rainfall, whereas jhum is prevalent in the regions with lesser rainfall (NEPED and IIRR 1999). In traditional jhum practices farmers cultivate crops for two consecutive years and leave the site fallow for 13-18 years. In recent times, due to increasing human population there has been intensification of agricultural practices to increase the crop yields. Such intensification makes significant changes in the traditional agricultural practices, for example jhum cycle (traditionally 15-20 years) reduces to 4-9 years, folk varieties of crops are gradually replaced with high yielding varieties and traditional systems gradually lose their resilience power. Shorter jhum cycle cannot give sufficient time for fallow regeneration. As a result, there is rapid decrease in soil fertility. These changes cause rapid deterioration of soil quality, further affecting crop yields and loss of genetic resources of traditional crop varieties which pose threat to food security (NEPED and IIRR 1999, Nakro 2011, Changkija 2014). In the light of the above, it is imperative to transform jhum into a sustainable system that can ensure food and energy security.

The Angami Naga tribe (in short Angami) of Nagaland state in Northeast India practice sustainable land use system in which there is cultivation of selected local tree species with traditional crops. Nhalie (jhum) and teizie (homegarden) are the two major forms of Angami agroforestry (Fig 1). Some reports described the alder-based farming in Khonoma village of Kohima district (NEPED and IIRR 1999, Cairns 2007, Chase and Singh 2014) and management of *Macaranga* sp. by another Naga tribe, Konyak (Changkija 2014). Diets of smallholding farmers mainly comprised of seasonally available agroforestry products and other wild edibles (Singh and Teron 2017). Surplus crop produce is exchanged among the farmers. They hardly procure foods from other sources since there is no proper market facilities and easy market accessibility in the Angami region (Senotsu and Kinny 2016). Wild edibles of frequent use are maintained in teizie for the ease of collection. Teizie contributes to the dietary supplementations of rural Angamis during the period of hungry months or off season. A review of various reports reveals scant information on the potential roles of traditional agroforestry among the Angamis. The present study aims to investigate the contribution of traditional agroforestry to food security among the Angami Nagas of Kohima district, Nagaland. Angami agroforestry harbours rich agrobiodiversity which constitutes vital ingredients of food habits of Angamis. The sustainable food systems of Angami agroforestry provide the food security and subsistence needs of smallholder farmers. Major challenges for the improvement of Angami agroforestry and procurement of food are also considered.

Figure 1. Major forms of Angami agroforestry, a Alder based *nhalie* in Khuzama village. b Oak based *nhalie* in Mima village. c Cultivation of *Parkia timoriana* in *nhalie* field of Dihoma village. d. A view of *teizie* (homegarden) (Photograph: 2018, Akoijam Basanta Singh)

MATERIALS AND METHODS

The study area and the people: Nagaland represents one of the eight states in Northeastern 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 (asl) covering a geographical area of 4041 sq km. The region is considered as the homeland of the Angami Naga or simply Angami, 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). The village may be considered as the unit of the political and religious parts of Angami life, whereas chienuo (clan) is the real unit of social structure. There are more than 100 clans and sub-clans of Angami Naga in the Angami villages of Kohima district. Each clan consists of an average of 40-50 families. A group of three or four clans constitutes a khel. 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. Rural Angamis rely mainly on their agroforestry products for their food and nutritional security. Wet terrace and jhum cultivation are the major forms of agricultural systems.

Collection of data: Field study was undertaken among the Angami Naga in Kohima district of Nagaland from March, 2016 to November, 2019. We obtained permission for field study and consents from the Chairmen of village councils and key informants, respectively. Villages of Angami regions, namely Khuzama, Jakhama,

Kigwema, Mima, Dihoma and Rusoma (Fig 2) were included for data collection. Data sampling started with ''walks-in-the-woods'' covering the six Angami villages. Each walk was guided by a local guide who explained Angami names and uses of plant species growing in agroforestry fields. Though the walk-in-the-woods approach is time consuming, it is reliable, and it allows for a small number of participants (Thomas et al. 2007). A checklist of plants growing in Angami agroforestry fields was prepared through group discussions and personal observations in the field (Vogl et al. 2004). Thirty eight elderly farmers who have experience in agroforestry for more than 10 years were selected for group discussions. We discussed on traditional knowledge of propagation and management of each plant species cultivated in nhalie and teizie and recorded information of plants along with their local names. Group discussion with farmers and village elders gave an opportunity to the informants to share their knowledge in different aspects of the management of plant species in their fields. Other information relevant to the objectives of our study was recorded from the discussion. Data on crop diversity and utilization was collected through semi-structured interview of 40 farmers (Gerique 2006), and the data was transferred in excel sheet for analysis. In the semi-structured interview, we asked open-ended questions on socio-cultural and economic importance of various crops, yields, size of agricultural plots and traditional knowledge of post-harvest techniques, processing and storage of crops. Average yields of crops of 10 households was calculated using Microsoft excel 2016. Plant specimens were collected from agroforestry fields with the help of informants and identified with the help of local floras (Kanjilal et al. 1934-1940). Nomenclature and family delimitation for the recorded plants were updated using online database *The Plant List* (www.theplantlist.org).

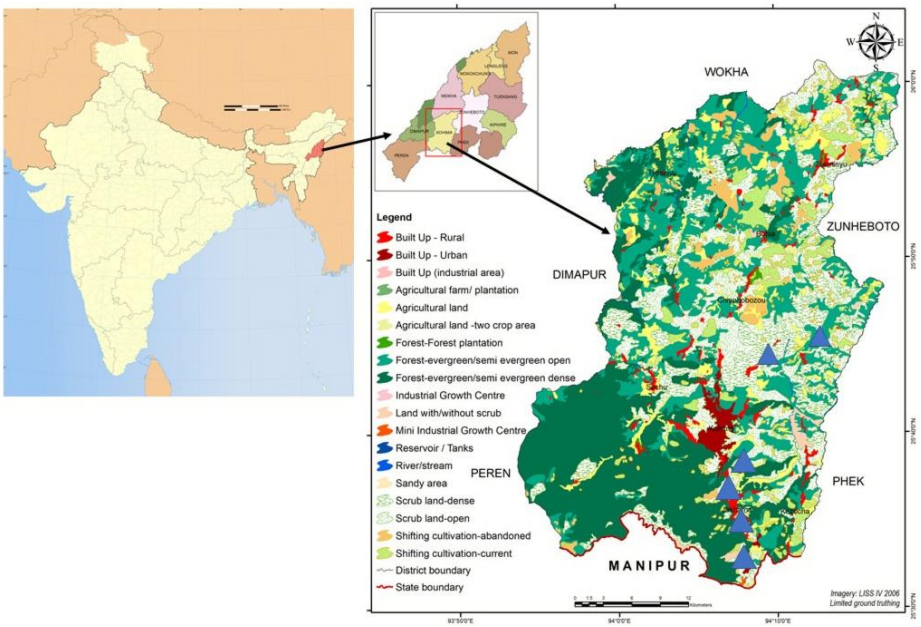

Figure 2. Map of Kohima district showing places (shaded triangles) where field study was undertaken (Source: Nagaland GIS and Remote Sensing Centre Planning and Co-ordination Department, Government of Nagaland).

RESULTS AND DISCUSSIONS

Traditional agroforestry and Angami Naga subsistence practice: Traditional agriculture is an indigenous form of farming which is the result of the co-evolution of local, social and environmental systems (Nakro 2011). Different agroecosystems have evolved over time as farmers adopted new agricultural practices to meet the basic needs for food, medicine, fodder, firewood, livelihood, and other utilities (NEPED and IIRR 1999). Angami Nagas practice indigenous sustainable farming systems through the integration of various multipurpose tree species in their nhalie fields suitable for the local ecological settings.

Significant factors that determine the location and distribution of Angami agroforestry systems include altitude, slope, temperature, precipitation, soil fertility status and the distance between the field and the place of habitation (Nakro 2011). Composition of tree species in Angami agroforestry varies with altitudes. Farmers cultivate alder (*Alnus nepalensis*) in altitude ≥ 1000 m asl whereas below 1000 m asl tree species, namely *Quercus serrata*, *Melia azedarach*, *Toona* sp., *Albizia lebbeck*, *Phyllanthus emblica*, *Parkia timoriana* and *Schima wallichii* are cultivated. Alder based traditional agroforestry systems are prevalent in hilly regions of Nepal and other adjoining Himalayan regions including Northeastern regions of India (Rana et al. 2018). In Khonoma village of Kohima district alder-based agroforestry helps to intensify agriculture by reducing nhalie cycle to 4 years of from 2 years for cultivation followed by fallow of 2 years without negative bearing on environment (Cairns 2007). The entire community collectively decide to select new nhalie site, leaving the preceding field to lie fallow. In the first cropping year farmers start slash and burnt operation and prepare the soil for cultivation. Farmers establish new seedlings of alder, whether self-grown or intentionally planted. They grow rice and other secondary vegetable crops. On maturity crop is harvested, processed and stored for next season. Surplus produce is sold in return for cash benefit or exchanged with other crops. The same crop operation is repeated in the second year. After the harvest of second year crops the field is left fallow. After two or three nhalie cycles the alder trees are pollarded horizontally with a sharp dao (knife) at a height of 2.13-2.44 m above the ground (Fig 3a). New coppices sprout from all sides of the cut end of pollarded stems (Cairns 2007).

Whereas, in Mima village instead of alder farmers manage oak (*Quercus serrata*) as fallow tree in their nhalie fields without compromising crop yields. Natural populations of alder have not been sited around Mima village, probably local environment is not suitable for the plant. Each household is responsible for the selection of sites for cultivation. After selection of a site, farmers start preparation of field with clearing of vegetation usually with dao (knife) from the last week of October and continue till the end November. In the first year of crop cultivation farmers transplant oak seedlings or some grow directly from soil seed bank at different sites of the field. Farmers sow rice as dominant crop along with seeds of other crops, namely maize (*Zea mays*), chillies (*Capsicum annuum*), cucumber (*Cucumis sativus*), pumpkin (*Cucurbita maxima*), tomato (*Lycopersicon esculentum*), *Perilla frustescens* etc. in April. After germination, plantlets of different crops are transplanted at suitable places in the field with proper spacing. Pumpkin and cucumber are transplanted at the edge of the plot so that they will not interfere with growth of rice. Beans which need support are grown near pruned small trees inside the field. Farmers do first weeding in May and second weeding in July. Harvesting of crops begins from

late July. Intense cultivation of oak begins in second year with spacing of about 1.52 m randomly throughout the entire field. During the fallow period of 10 to 15 years, coppices of the pollarded stems grow to decent size which is harvested for firewood (Singh and Teron 2019). *M. azedarach* is another important fast-growing agroforestry tree cultivated for timber. The tree is logged for timber closer to the ground but not maintained in the agroforestry fields for producing coppices. Sometimes farmers also grow *Toona* sp. and *S. wallichii* for timbers; *A. lebbeck* and *P. emblica* for firewood, but they are less common. Natural population of oak trees of about 7-10 years (considered as most desirable age) are pollarded horizontally at the height of 0.61 to 0.91 m above the ground (Fig 3b). Thinning is done for small and young trees which are less than 7 years. In the second year, as many as 20 to 30 coppices develop from the lateral side of the stem which is usually thinned to 2 coppices (Singh and Teron 2019).

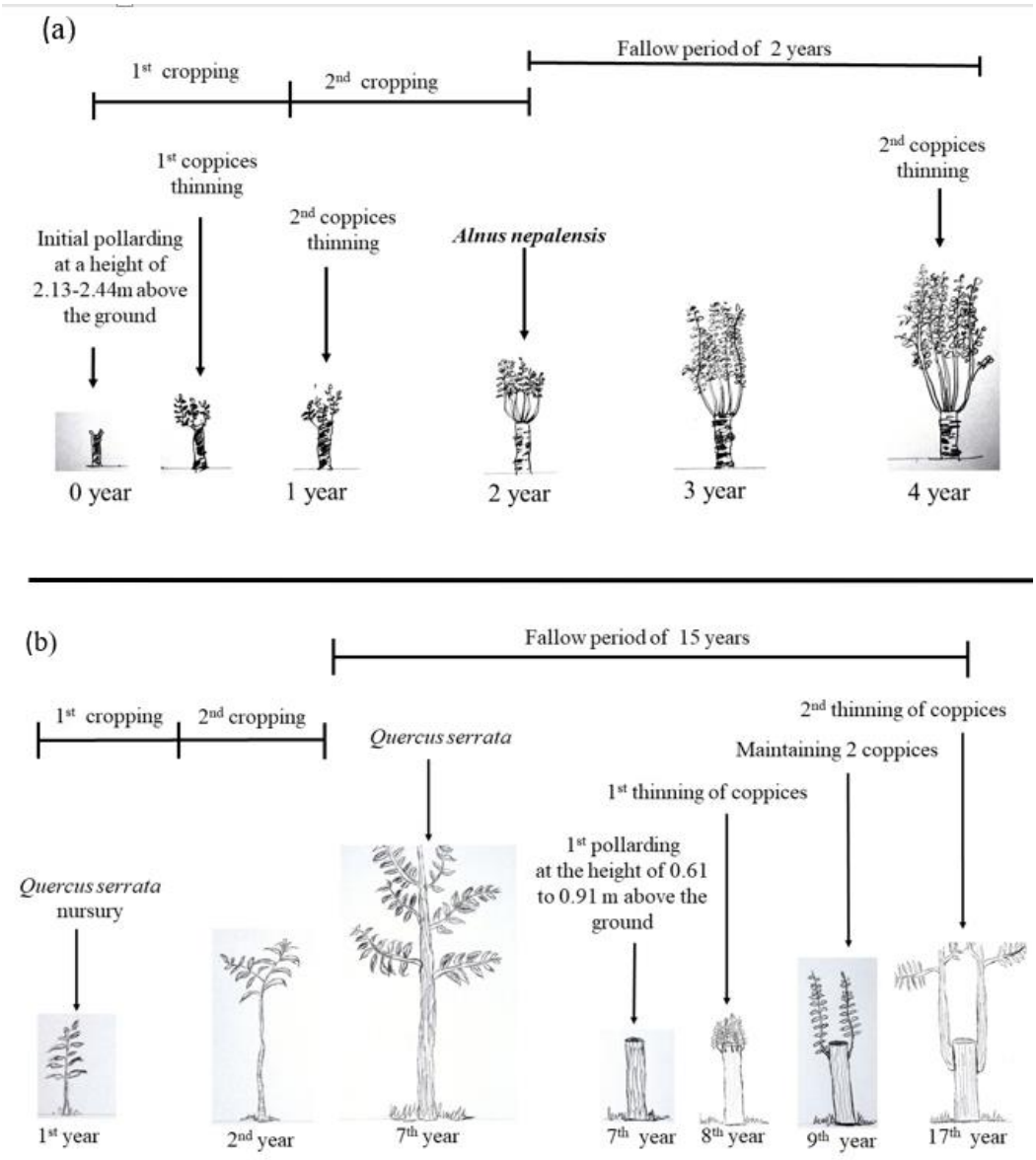

Figure 3. Schematic representation of fallow management in Angami agroforestry, a Management of alder in Khonoma village (Cairns 2007). b Management of oak in Mima village.

Angami farmers follow traditional soil and weed management techniques. They do not apply manures or fertilizers in their crop fields. Instead they add ashes and charcoals obtained from the burning of plants debris

and weeds, in the fields for neutralizing the acidic soil (Changkija 2014). Herbicides, insecticides and fungicides are seldom used. Seeds and other perennial underground vegetative parts of weeds are expected to perish while burning of soil during its preparation. Regular practice of manual removal of weeds is considered the most essential approach of controlling weeds. Burning of slash helps to drive away rodents far from the field and many pests, including insects existing in the soil are expected to die (Singh and Teron 2019).

Most Angami teizie are small in area. Teizie is made by constructing small terraces on the slope of hillsides. Sometimes terraces are not constructed and plants are cultivated directly on the hill slopes. Teizie is usually fenced with barbed wire, bamboo, *Persicaria chinensis*, *Polygonum molle* or *Polygonum* sp. There are three different types of teizie maintained by the Angami Nagas- (i) a small kitchen garden around the house with small plots for vegetables and one or two fruit trees; (ii) tejeye- larger traditional home gardens away from the house situated on terrace fields on the upper level and cultivated like home gardens for commercially important crops such as potatoes and fruit trees, and (iii) mejye- community home gardens on community owned terraced fields cultivated like home gardens. Management practices are different for these three types of teizie (Godbole 1998). Maintenance of teizie is mainly done by women. Women are responsible for all onerous household activities like farm works, agriculture, collection of food plants and many more. So, women play key roles in the overall organization and management of teizie. Besides foods and fruits, many plants are cultivated in teizie for medicine and animal feeds. But the choice of species to be grown in teizie depends upon the interest and economic needs of the owners. In teizie many ornamental plants are grown; this is suggestive of the view that aesthetic sense is also another important feature of teizie. Ornamental plants are usually grown on the side of teizie. They are also planted in flowering pots.

Post-harvest processing/storage management: Appropriate storage and efficient processing and preservative techniques can help in promoting food security by adding value to the products and increasing their shelf-life (Adeyeye 2017). Angami farmers preserve post farm products in the form of seeds, rhizomes, bulbs and tubers for the purpose of rising next year crops or future use as foods. Some common traditional methods for preserving crops include sun drying, drying above furnace, hanging on the roof or veranda of house and spread over cold ground. Seeds are stored in bamboo cylinder or cylinder made from dried pericarp of *Luffa cylindrica* and pumpkin and kept in the environment of traditional smoke filled kitchen which is not favourable to storage pests (Changkija 2014). Maize, garlics (*Allium sativum*), *Allium chinense* and *Allium ascalonicum* are preserved by hanging on the roof of house for sun drying or sometime drying above furnace. These techniques help to minimize the damages caused by pests. Angamis store rice grains in adequate and efficient granary. Angami rice granary is a big bamboo basket knitted artistically with local bamboo species called vüpra and ratho. It is cylindrical in shape with narrow opening at the top which is covered with a conical shaped bamboo basket. This cover knitted with inner soft pulp of bamboo has numerous pores for air passages that helps to avoid fungal infection on rice by reducing moisture content inside granary. The structure of rice granary is lined with two layers of bamboo mats. Outer layer is made up of thin hard outer epidermal layer of bamboo, while inner layer is made up of soft inner pulp. The granary is placed on raised cement or wooden platform to avoid direct contact with ground. This not only helps to increase the life of granary but also avoid rodents. Improvement in the

techniques of storage and preservation of farm products will help to reduce loss from post-harvest damage which is also a factor of food insecurity.

Diversity of crops and wild harvested plants: The present study documented 32 species under eight types of crop cultivated in nhalie on the basis of their primary uses (Balasubramanian 2014). The distributions of food plants under major types of crop are cereals (5 species), roots and tubers (2), legumes or pulses (9), fruit vegetables (7), leafy vegetables (2), spices and condiments (6), oilseeds (1) and forage (2) (Table 1). Nineteen cultivars of rice cultivated in nhalie were reported from three Angami villages, namely Mima, Rusoma and Dihoma.

This study observed rich agrobiodiversity in teizie with 71 species under six major types of crops, namely cereal crops, vegetable crops, fruit crops, cash crops, sugar crop and spice crops based on the primary uses (Fig 4) (Balasubramanian 2014). Richness of species was more in teizie than in nhalie; 18 species were cultivated in both nhalie and teizie. Vegetable crops were classified into 5 types based on their edible parts: leafy vegetables (7 species), shoot vegetables (13), pod and seed vegetables (6), root and bulb vegetables (7), flower vegetables (2) and fruit vegetables (9). Major vegetable crops include potato (*Solanum tuberosum*), cabbage (*Brassica oleracea* var. *capitate*), broccoli (*Brassica oleracea* var. *italica*), lablab beans (*Lablab purpureus*), peas (*Pisum sativum*), beans (*Phaseolus vulgaris*), lettuce (*Lactuca sativa*), mustard (*Brassica rapa*), squash (*Sechium edule*), *Luffa cylindrica*, *Vicia faba*, *Hibiscus sabdariffa* and *Cyphomandra betacea*; fruit crops include climbers, shrubs and trees, for examples orange (*Citrus* sp.), *Citrus limon*, *Punica granatum*, *Passiflora edule*, *Rhus chinensis*, *Prunus persica*, *Psidium guajava*, *Artocarpus heterophyllus*, and *Actinidia* sp.; cash crop includes *Cannabis sativa*; sugar crop includes sugarcane (*Saccharum officinarum*); spices include *Eryngium foetidum*, *Elsholtzia blanda*, *Mentha spicata*, *O. tenuiflorum,* chillies and ginger.

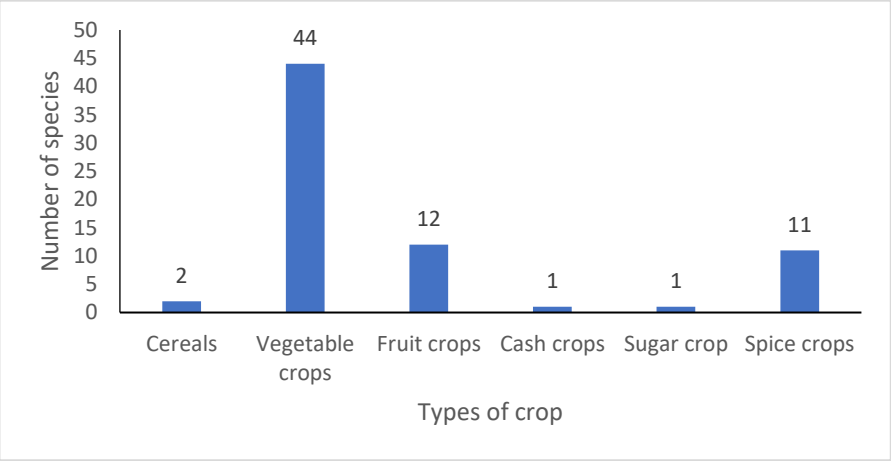

Figure 4. Agrobiodiversity in Angami *teizie*

Angami Nagas manage pretty good number of wild edible plants in their teizie which are maintained closer to houses and more convenient for the collection of wild edibles than nhalie fields which are located at far distance from the residential areas. Plants of restricted distribution and frequent use are usually cultivated in teizie for easy availability. Many edible plants which grow as weeds in teizie are allowed to grow as a source of food supplements. Wild edibles constitute vital ingredients of different traditional dishes (Singh and Teron

2017) (Fig 5). Teizie contributes 29 species of wild edibles during off season. Notable species are *Amaranthus spinosus*, *Amaranthus* sp., *Chenopodium album*, *Diplazium esculentum*, *Elatostema* sp., *Ficus auriculate*, *Houttuynia cordata*, *Cardamine hirsute*, *Oenanthe javanica*, *Centella asiatica*, *Gynura nepalensis*, *Clerodendrum colebrookianum*, *Spilanthes acmella*, *Impatiens arguta*, *Bambusa* sp., *Musa* sp., *Plantago asiatica*, *Rumex nepalensis*, *Stachytarpheta jamaicensis*, *Fagopyrum esculentum*, *Persicaria nepalensis*, *P. chinensis* and *P. molle*. This demonstrates teizie plays a significant role in filling the gap of off season as source of food. Further, teizie can be a good reserve of genetic resources of wild relatives of many cultivated plants. Cultivation of important wild edible plants in teizie helps to reduce pressure from the ever increasing collection pressure of wild resources. As a result, many wild populations of edible plants remain untouched. This will ultimately lead to *in-situ* conservation of wild edible plants.

Table 1: Agrobiodiversity in *Nhalie* agroforestry

Sl. No.	Crop type	Food plants [Family]	Number of cultivars
1	Cereals	*Oryza sativa* L. [Poaceae]	19
		Zea mays L. [Poaceae]	3
		Coix lacryma- jobi L. [Poaceae]	2
		Setaria sp. [Poaceae]	3
		Sorghum sp. [Poaceae]	1
2	Roots and tubers	*Colocasia esculenta* (L.) Schott [Araceae]	8
		Zingiber officinale Roscoe [Zingiberaceae]	2
3	Pulses/legumes	*Vigna* sp. [Leguminosae]	7
		Lablab purpureus (L.) Sweet [Leguminosae]	3
		Phaseolus vulgaris L. [Leguminosae]	4
		Glycine max (L.) Merrill [Leguminosae]	2
		Parkia timoriana (de Candolle) Merrill [Leguminosae]	1
4	Fruit vegetables	*Cucumis sativus* L. [Cucurbitaceae]	4
		Cucurbita maxima Duchesne [Cucurbitaceae]	4
		Lagenaria siceraria (Molina) Standl. [Cucurbitaceae]	3
		Solanum melongena L. [Solanaceae]	4
		Benincasa hispida (Thunb.) Cogn. [Cucurbitaceae]	2
		Lycopersicon esculentum Miller [Solanaceae]	2
		Sechium edule (Jacquin) Swartz [Cucurbitaceae]	5
5	Spices and condiments	*Capsicum annuum* L. [Solanaceae]	2
		Perilla frustescens (L.) Britton [Lamiaceae]	2
		Allium sativum L. [Liliaceae]	1
		Allium chinense G. Don [Liliaceae]	1
		Allium ascalonicum L. [Liliaceae]	1
		Ocimum tenuiflorum L. [Lamiaceae]	1
6	Leafy vegetables	*Hibiscus cannabinus* L. [Malvaceae]	1
		Hibiscus sabdariffa L. [Malvaceae]	1
7	Oil seeds	*Helianthus annuus* L. [Asteraceae]	1
8	Forage	*Zea mays* L. [Poaceae]	3
		Colocasia esculenta (L.) Schott [Araceae]	8

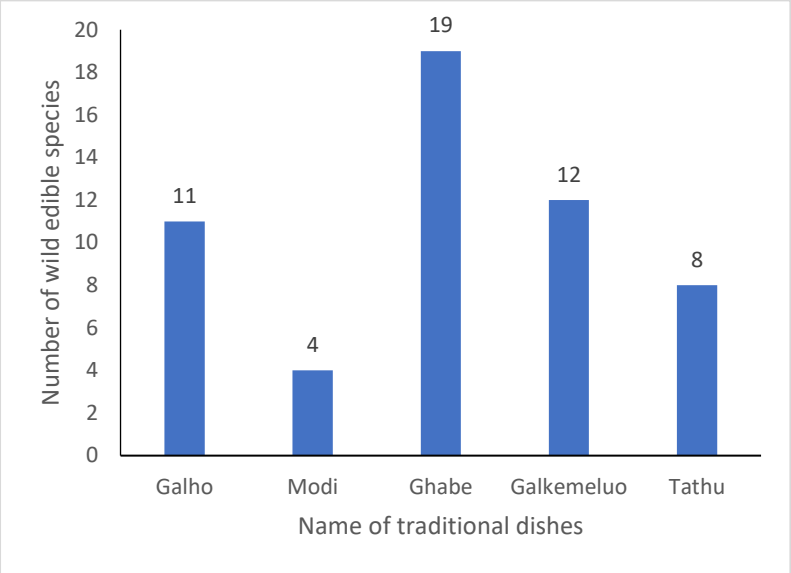

Figure 5. Distribution of wild edibles in Angami traditional dishes

Agrobiodiversity and food security: Nhalie and teizie are the main sources of agrobiodiversity. Diverse crops and wild edibles in Angami agroforestry provide the continuous accessibility to food for smallholder farmers. Agrobiodiversity significantly contributes to food and nutritional security for the poor rural Angamis.

Procurement of foods: Usually crop cultivation commences in April after first shower and continues up to September. This means the crops mature at different time of the year and allows harvesting throughout the year thus, ensuring food security. Brinjal (*Solanum melongena*) is harvested consecutively for two years (first year- June to November and second year- April to November). Soyabean (*Glycine max*) is cultivated twice in a year, April and August and harvested in October and January, respectively. *A. ascalonicum* is harvested from June to September. In September farmers cultivate garlic and harvest in January and February. There is continuous access to diverse food crops in nhalie for nine months in a year (Table 2). Off season starts from January and continues till the end of March which is compensated with nhalie products such as taro (*Colocasia esculenta*), beans, rice beans (*Vigna* sp.), lablab beans, ash gourd (*Benincasa hispida*) and *P. timoriana*. Home gardens provide continuous source of foods throughout the year (Table 2). Off season foods like cabbage, broccoli, peas, lettuce, squash, mustard, brinjal, *Momordica charantia, Vicia faba*, lablab beans, beans, *C. betacea*, *Capsicum chinense*, *Musa* sp. and *Smallanthus sonchifolius* are obtained from teizie. Angamis harvest rice and other cereal crops (maize, foxtail-millets (*Setaria* sp.) and *Sorghum* sp.) from nhalie prior to harvest of wet terrace produce. Cereal crops from nhalie are the primary source of dietary supplement for staple food of smallholder Angami farmers. Fermented bamboo shoots serve as viable source of food for off season since they can be kept for longer days. Leaves of taro, *Hibiscus cannabinus* and *H. sabdariffa* and pods of *P. timoriana* are sun dried and preserved for off season. Fruits of *R. chinensis* are sun dried and grinded into powder. This dried power of fruits can be stored for longer days for future use. Fruits of *P. emblica* and *Docynia indica* are cut into slices and sun dried and stored for future consumption. Such dried fruits help to supplement nutrient needs during off season.

Table 2: Crop diversity and accessibility in Angami agroforestry fields at different times of a year

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
					Nhalie							
Oryza sativa L.								✓	✓			
Zea mays L.						✓	✓	✓	✓	✓		
Setaria sp.							✓	✓				
Sorghum sp.												
Solanum melongena L.				✓	✓	✓	✓	✓	✓	✓	✓	
Cucumis sativus L.						✓	✓	✓	✓			
Cucurbita maxima Duchesne								✓	✓	✓	✓	✓
Colocasia esculenta (L.) Schott	✓							✓	✓	✓	✓	✓
Phaseolus vulgaris L.	✓					✓	✓	✓	✓	✓	✓	✓
Vigna sp.	✓							✓	✓	✓	✓	✓
Lablab purpureus (L.) Sweet	✓										✓	✓
Benincasa hispida (Thunb.) Cogn.	✓										✓	✓
Sechium edule (Jacquin) Swartz						✓	✓	✓	✓	✓	✓	✓
Parkia timoriana(de Candolle) Merrill	✓	✓										✓
Lycopersicon esculentum Miller						✓	✓	✓	✓	✓	✓	✓
					Teizie							
Brassica oleracea var. *capitate* L.	✓	✓	✓	✓	✓						✓	✓
Brassica oleracea var. *italica* Plenck	✓	✓	✓								✓	✓
Brassica rapa L.	✓	✓	✓	✓	✓						✓	✓
Lactuca sativa L.	✓	✓									✓	✓
Momordica charantia L.	✓	✓						✓	✓	✓	✓	✓
Vicia faba L.	✓	✓	✓								✓	✓
Cyphomandra betacea (Cav.) Sendtn.	✓	✓	✓							✓	✓	✓
Musa sp.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Smallanthus sonchifolius (Poepp.) H. Rob.				✓	✓							

Many farmers perceive that the pattern of mixed cropping in agroforestry fields helps to augment yields of crops. Crops such as, maize, pumpkin, cucumber, taro, ginger, *A. ascalonicum*, beans etc. produced through nhalie practice are sufficient for annual household consumptions (Fig 6). However, rice production is insufficient since the area of cultivation is small. Though rice production from nhalie is less, it helps to supplement rice from terrace specially during food insecure period or hungry months before the harvest of wet terrace cultivation. In addition, nhalie is also the primary source of fodder for livestock such as pig and pasture for cattle. Maize and taro are major source of feeds for pig. Meat such as pork and beef is important constituent of the food habits of Angamis.

There is no proper market facilities and easy market accessibility in many Angami villages because of poor conditions of road and lack of public transportation. Rural Angamis need to walk longer distance around 10-40 km for any business deal in town areas (Senotsu and Kinny 2016). As a result rural Angami farmers hardly procure food from other sources and mainly rely on their nhalie products and other wild edibles for their food security.

Livelihood security: Food security is not just dependent on increased yield (FAO 2015, World Bank 2015) as livelihood security is also a critical component to solve major hunger crises. Livelihood can be defined as the capabilities, assets and activities required for a means of living (Kehie et al. 2017). Combining with the low cost production and augmentation of crop yields, agroforestry can increase net income which helps to deprive of poverty (a major driver of hunger) from among farmers (World Bank 2015, Waldron et al. 2017, Miller et al.

2017). Firewood from nhalie is also another source of earning cash income among the Angamis. The quantity of firewood for sale is measured in a local unit called thai that includes firewoods of 0.91 m in length which are piled up in a stack measuring 3.05-3.66 m in length and 1.1 m in height. The cost of one thai of firewood is INR 4000-6000. Nhalie thus, contributes towards the livelihood security of farmers by improving economic standard and purchasing power to meet their basis needs.

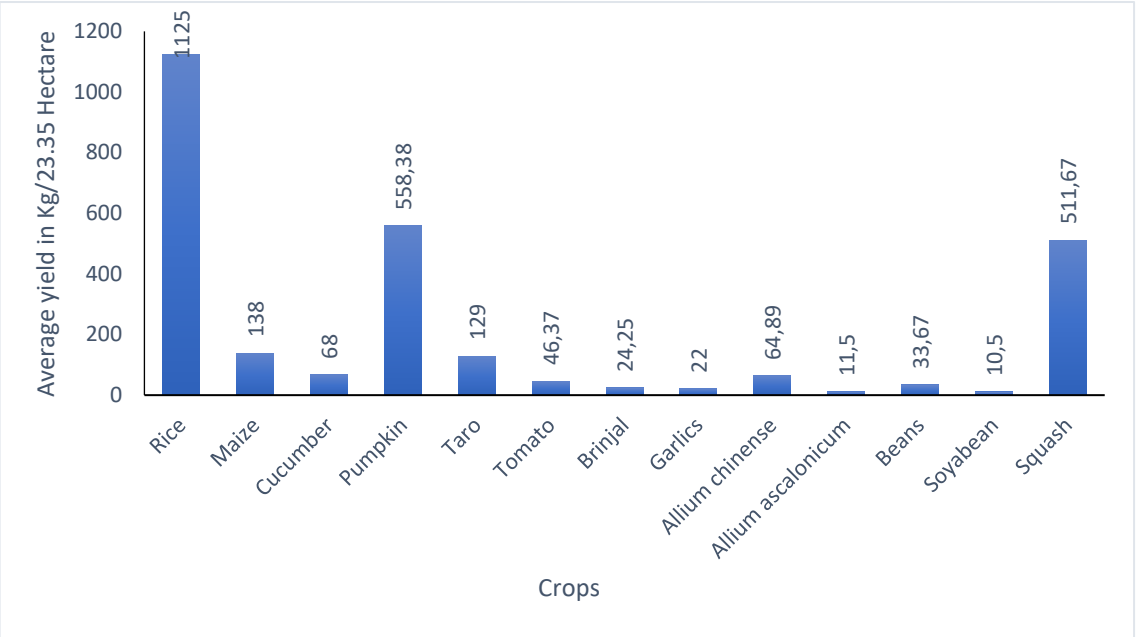

Figure 6. Average yields of thirteen selected crops of ten households in Rusoma village, Kohima district.

Energy security: In Angami regions firewood is one of the most important needs of a family's existence. It is used not only in cooking but also for heating homes during cold winter, making charcoal and other utilities (Nakro 2011). The increasing pressure from firewood and timber extractions results in serious issues of deforestation in Nagaland state. Deforestation causes massive destruction of the habitats of wildlife and ecological imbalance which pose threat to food security. Supply of firewood from agroforestry represents an important, hunger-related form of energy security for rural communities (Sharma et al. 2016). Nhalie involving management of local tree species in nhalie fallow supplement to meet the increasing local needs of energy without compromising agricultural productivity. Alder is the most popular fallow tree which provides firewood in Kohima district of Nagaland. In other region of Nagaland notable firewood and timber trees are *Q. serrata, P. emblica, A. lebbeck, S. wallichii, Toona* sp. and *M. azedarach*, *Quercus griffithii* and *Lithocarpus polystachyus.* Angamis preferred *Q. serrata* to other species of oak since it can produce more coppices. Farmers reported that firewood obtained from *L. polystachyus* is highly resistant to weathering and could be kept in stacks in open place for more than 2 years, while firewood of *Q. serrata* and *Q. griffithii* hardly last for one year. In terms of quality firewood and charcoal obtained from oak trees is better than the most popular traditional tree *A. nepalensis*. Studies have revealed, agroforestry not only helps to enhance coproduction of food and firewood but also gives multiple ecosystem services which include maintaining soil fertility, reducing soil erosion and mitigation of climate change (World Bank 2015, Sharma et al. 2016).

Future prospects of Angami agroforestry: Angami regions is located in the huge mountain terrains of eastern Himalayan ranges. Such topographical features do not favour the possibility of easy construction of terraces for permanent cultivation since it involves intense physical labour (NEPED and IIRR 1999). Either, replacement of nhalie with permanent terrace cultivation will not be feasible to large extent. In Dihoma village where terrace is hardly constructed, nhalie and teizie are the only alternatives for agriculture. Further, cultivation in the permanent terrace fields has limitations which include flooding and nutrient leaching due to poor management and lack of irrigation channels (Singh and Jamir 2017). As a result essential nutrients gradually deplete in soil and crop yields decrease. However, in nhalie fallow regeneration replenishes nutrients in soil for rising crops in the next nhalie cycle leading to increase in crop yields.

Nhalie will persists as means of subsistence among the smallholder farmers in the generations to come. There is need for sincere efforts to maintain the sustainability of traditional agriculture for food, energy and livelihood security of rural Angamis. Major challenges which can be addressed for the improvement of nhalie include increasing the duration of fallow regeneration; selection of fast growing tree species for fallow regeneration suitable for different agroclimatic zones through the process of field trial and observations; motivation of local communities to adopt agroforestry practices in their nhalie fields; innovations for intensifying agriculture by reducing fallow period without significant negative bearings on environment to meet the needs of increased population.

Alder-based agroforestry of Khonoma village can be extended to other Angami villages, namely Khuzama, Viswema, Jakhama and kigwema, where alder can grow successfully. This will help to allow faster rotation of available sites of cultivation by reducing fallow period to 2-3 years and boost agriculture productivity without further expanding agricultural land to new forest areas. The symbiotic association of roots of alder and *Frankia* results in biological nitrogen fixation (Chase and Singh 2014). Further, when the leaves of alder fall on the ground and decompose, it also helps to increase nutrient contents of the soil. *P. timoriana* also has symbiotic association with *Rhizobium* sp. as nitrogen fixers (Hammer and Khoshbakht 2015). *A. lebbeck* and *Leucaena leucocephala* also are suitable tree species capable of biological nitrogen fixation (Pokhriyal et al. 1987). Angami farmers may be encouraged to cultivate *A. nepalensis*, *P. timoriana*, *A. lebbeck* and *L. leucocephala* in their nhalie for the sustainable management of soil which is the key to food security.

As conclusion, nhalie of the Angami Nagas is the sustainable resource management and land use system in which selected multipurpose local tree species are cultivated with traditional crops. Both nhalie and teizie are primary sources of food, medicine, firewood, fodder, cultural needs, livelihoods and other utilities of equal importance. As of now, nhalie will continue among Angamis as sources of subsistence and livelihoods till alternative environmentally sound practice is introduced. Angami agroforestry not only enhances food security but it is also the exhibition of their rich traditional knowledge system which can be modelled as a tool for conservation of agrobiodiversity and sustainable rural development. There is pressing necessity for holistic study of Angami agroforestry practices in different agroclimatic zones of Angami regions to ensure steadfast food and energy security. Pretty good number of wild edibles and conventional crops growing in teizie contributes towards supplementing food during off season. Teizie can become natural sink by reducing collection pressure

on wild plants where crops and cultivated wild plants will augment food production. It can further intensify the process of plant domestication accompanied by genetic diversification and contribute to conservation of plant genetic resources. The present study will help to draw attention of the authorities and policy makers to extend their support to renovate the existing nhalie of Angamis as sustainable agroecosystems by encouraging to cultivate suitable multipurpose fallow trees in different agroclimatic zones, and further strengthen the role of Anagmi agroforestry practices in the subsistence and livelihoods of the rural Angamis.

ACKNOWLEDGEMENT

Authors are grateful to Angami farners for sharing their traditional knowledge on agroforestry. We thank local guides for their assistance and hospitality during field study. Special thanks to Mr. Kevikhrietuo Ngukha, Mr Khovi Ngukha, Mr Menosale Kere and Mrs Banuo Kire for their assistance during field visits. Authors would like to thank Institutional Biotech Hub (Department of Biotechnology, Government of India), Department of Life Science & Bioinformatics, Assam University – Diphu Campus, Assam for infrastructural support.

REFERENCES

Abdulhamid, B., Abubakar, E.M. and Dawaki, S.A. 2017. An assessment of potential contributions of agroforestry to food security in Katsina, Sudan Savannah Area, Nigeria. Current Life Sciences 3(3): 39-46.

Adeyeye, S.A. 2017. The role of food processing and appropriate storage technologies in ensuing food security and food availability in Africa. Nutrition & Food Science 47(1):1-18.

Basic Facts Nagaland. 2018. Directorate of Information and Public Relations, Government of Nagaland, Kohima. 2 pp. https://ipr.nagaland.gov.in/. (Visited 08th May 2020).

Balasubramanian, A. 2014. Classification of agricultural crops. Technical Report. https://www.researchgate.net/publication/314205688. (Visited 29th March 2019).

Cairns, M. 2007. The Alder Managers: The Cultural Ecology of a Village in Nagaland, N.E. India. PhD Dissertation, Australia National University, Canberra. 31-34 pp.

Changkija, S. 2014. Biodiversity of Nagaland. Department of forest, ecology, environment and wildlife. Government of India, Kohima. 32-41 pp.

Chase, P. and Singh, P.O. 2014. Soil nutrients and fertility in three traditional land use system of Khonoma, Nagaland, India. Resources and Environment 4(4):181-189.

Dawson, I.K., Place, F., Torquebiau, E. et al. 2013. Agroforestry, food and nutritional security. Background paper for the 4thInternational Conference on Forests for Food Security and Nutrition. FAO, Rome. http://www.fao.org/forestry/82456/en/. (Visited 08th May 2020).

FAO, WFP and IFAD. 2015. The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress. Rome. http://www.fao.org/3/a-i4646e.pdf. (Visited 08th May 2020).

Gerique, A. 2006. An Introduction to ethnoecology and ethnobotany. Theory and Methods - Integrative assessment and planning methods for sustainable agroforestry in humid and semiarid regions. Advanced Scientific Training – Loja, Ecuador. 7-9 pp. https://www.researchgate.net/publication/239591352. (Visited 08th September 2020).

Godbole, A. 1998. Angami Homegardens. In: A. Rastogi, A. Godbole & P. Shengji (eds.). Applied Ethnobotany in Natural Resource Management- Traditional. ICIMOD, Kathmandu. p. 65-70.

Hammer, K. and Khoshbakht, K. 2015. A domestic assessment of the big five plant families. Genetic Resources and Crop Evolultion 62(5):665-689.

Huang, W., Luukkanen, O., Johanson, S., Kaarakka, V., Räisänen, S. and Vihemäki, H. 2002. Agroforestry for biodiversity conservation of nature reserves: functional group identification and analysis. Agroforestry Systems 55:65–72.

Hoosbeek, M.R., Remme, R.P., Rusch, G.M. 2018. Trees enhance soil carbon sequestration and nutrient cycling in a silvopastoral system in south-western Nicaragua. Agroforestry Systems. https://doi.org/10.1007/s10457-016-0049-2.

Jemal, O., Callo-Concha, D. and van Noordwijk, M. 2018. Local Agroforestry Practices for Food and Nutrition Security of Smallholder Farm Households in Southwestern Ethiopia. Sustainability 10: 2722.

Kahane, R., Hodgkin, T., Jaenicke, H. et al. 2013. Agrobiodiversity for food security, health and income. Agronomy and Sustainable Development 33: 671-693.

Kanjilal, U.N., Kanjilal, P.C., Das, A. and Purkaystha, C. 1934. Flora of Assam, Vol. 1, Assam Govt. Press, Shillong.

Kanjilal, U.N., Kanjilal, P.C. and Das, A. 1938. Flora of Assam, Vol. 2, Assam Govt. Press, Shillong.

Kanjilal, U.N., Kanjilal, P.C., Das, A. and Dey, R.N. 1939. Flora of Assam, Vol. 3, Assam Govt. Press, Shillong.

Kanjilal, U.N., Kanjilal, P.C., Das, A. and Dey, R.N. 1940. Flora of Assam, Vol. 4, Assam Govt. Press, Shillong.

Kehie, M., Khamu, S. and Kehie, P. 2017. Indigenous alder based farming practices in Nagaland, India: A sustainable agricultural model. Journal of Traditional and Folk Practices 5(2):82 – 152.

Kuyah, S., Whitney, C.W. and Jonsson, M. et al. 2019. Agroforestry delivers a win-win solution for ecosystem services in Sub-Saharan Africa. A meta-analysis. Agronomy and Sustainable Development 39: 47.

Limon, S.H., Hossain, M. and Spiecker, H. 2018. Nutrients leaching from green leaves of three potential agroforestry tree species. Agroforestry Systems 92:389.

Miller, D.C., Munoz-Mora, J. and Christiaensen, L. 2017. Prevalence, economic, contribution and determinants of trees on farms across Sub-Saharan Africa. Forest Policy Econ. https://doi.org/10.1016/j.forpol.2016.12.005

Nakro, V. 2011. Traditional agricultural practices and sustainable livelihood. A thematic report 2009. Department of planning and Coordination, Government of Nagaland, Kohima.12-27 pp.

NEPED and IIRR. 1999. Building upon Traditional Agriculture in Nagaland, India. Nagaland Environment Protection and Economic Development, Nagaland, India and International Institute of Rural Reconstruction, Silang, Cavite, Philippines. 21-31 pp.

Pokhriyal, T.C., Raturi, A.S., Pant, S.P., Pande, S.K. and Bhatnagar, S.K. 1987. Nitrogen fixation in Albiza, Acacia, Dalbergia and Leucaena leucocephala. Indian For 113(5):366-369.

Punyu, K. 2010. Oral history of the Angami Nagas. PhD Thesis, North East Hills University. 7 pp.

Quandt, A., Neufeldt, H. and Mccabe, J.T. 2018. Building livelihood resilience: what role does agroforestry play? Clim Dev. https://doi: 10.1080/17565529.2018.1447903

Rana, S.K., Rana, H.K., Shrestha, K.K., Sujakhu, S. and Ranjitkar, S. 2018. Determining bioclimatic space of Himalayan alder for agroforestry systems in Nepal. Plant Diversity 40:1-18.

Senotsu, M. and Kinny, A. 2016. Shifting cultivation in Nagaland: prospects and challenges. ENVIS Bulletin Himalayan Ecology 24:122-124.

Sharma, N., Bohra, B., Pragya, N., Ciannella, R., Dobie, P. and Lehmann, S. 2016. Bioenergy from agroforestry can lead to improved food security, climate change, soil quality, and rural development. Food and Energy Security 5(3):165-183.

Singh, P.K. and Jamir, A. 2017. Comparative study of soil fertility status of direct seeded and transplanted rice under Kohima district of Nagaland. Journal of Pharmacognosy and Phytochemistry (SPI): 64-68.

Singh, A.B. and Teron, R. 2017. Ethnic food habits of the Angami Nagas of Nagaland state, India. International Food Research Journal 24(3):1061-1066.

Singh, A.B. and Teron, R. 2019. Traditional oak agroforestry practices in Mima village of Kohima district, Nagaland state, Northeast India. Indian Journal of Hill Farming 32(2): 203-215.

Shukla, S., Pandey, V.V. and Kumar, V. 2018. Agroforestry Systems as a Tool In Sustainable Rural Development, Food Scarcity and Income Generation. Indian Forerter [S.l.]: 435-441.

Thomas, E., Vandebroek, I., Van Damme, P. 2007. What works in the field? A comparison of different interviewing methods in ethnobotany with special reference to the use of photographs. Economic Botany 61(4):376–384.

Vogl, C.R., Vogl-Lukasser, B. and Puri, R.K. 2004. Tools and methods for data collection in Ethnobotanical Studies of Homegardens. Field Methods 16(3):285-306.

Waldron, A., Garrity, D., Malhi, Y., Girardin, C., Miller, D.C. and Seddon, N. 2017. Agroforestry can enhance food security while meeting other sustainable development goals. Special Issue: Commercial Agriculture in Tropical Environments. Tropical Conservation Science 10:1-6.

Whitney, C.W., Luedeling, E., Hense, O., Tabuti, J.R.S., Krawinke, M., Gebauer, J. and Kehlenbeck, K. 2018. The role of homegardens for food and nutrition security in Uganda. Human Ecology. https://doi.org/10.1007/s10745-018-0008-9

World Bank. 2015. Ending poverty and hunger by 2030. An agenda for the global food system. Washington, DC. http://documents.worldbank.org/curated/en/700061468334490682/Ending-poverty-and-hunger-by-2030-an-agenda-for-the-global-food-system. (Visited 08th May 2020).

World Food Summit. 1996. Rome Declaration on World Food Security. World Food Summit, Rome. http://www.fao.org/3/w3613e/w3613e00.htm. (Visited 08th May 2020).

Received: 17th September 2020; Accepted: 01th Jule 2021; First reception: 17th October 2022.

Supplementary table 1: Food plants categorized into 5 food groups

Food groups (Description)	Name of plants	Parts used	Wild/ cultivated/both	Origin*	Food preparation**	Households #
Starchy staples (Cereals, white roots and tubers)	*Oryza sativa* L.	Seeds	Cultivated	n	b	100%
	Zea mays L.	Seeds	Cultivated	n	b, s	95%
	Sorghum sp.	Seeds	Cultivated	n	b	10%
	Coix lacryma- jobi L.	Seeds	Both	n	b	13%
	Eleusine sp.	Seeds	Cultivated	n	b	10%
	Solanum tuberosum L.	Tubers	Cultivated	n	b, f	10%
	Colocasia esculenta (L.) Schott	Corms	Both	n	b, f, ro	55%
	Manihot esculenta Crantz	Roots	Both	n	b	3%
	Smallanthus sonchifolius (Poepp.) H. Rob.	Tubers	Cultivated	e	b	3%
Dark green leafy vegetables (Dark green leafy vegetables, including wild forms, locally available vitamin A rich leaves)	*Amaranthus spinosus* L.	Young shoots	Wild	n	b	3%
	Amaranthus sp.	Young shoots	Wild	n	b	3%
	Manihot esculenta Crantz	Leaves	Both	n	b	3%
	Chenopodium album L.	Young shoots	Wild	n	b	3%
	Centella asiatica (L.) I. Urb.	Whole plants	Wild	n	b	24%
	Oenanthe javanica (Blume) de Candolle	Leaves	Wild	n	b	8%
	Gynura nepalensis de Candolle	Leaves	Wild	n	b	18%
	Brassica oleracea var. *acephala* L.	Leaves	Cultivated	n	b	3%
	Brassica oleracea var. *capitata* L.	Leaves	Cultivated	e	b	13%
	Brassica rapa L.	Leaves	Cultivated	n	b	31%
	Cucurbita maxima Duchesne	Young shoots and leaves	Both	n	b	58%
	Sechium edule (Jacquin) Swartz	Young shoots and leaves	Both	n	b	89%
	Clerodendrum colebrookianum Walp.	Leaves	Both	n	b	8%
	Hibiscus sabdariffa L.	Leaves	Both	n	b	10%
	Hibiscus cannabicus L.	Leaves	Both	n	b	10%
	Passiflora edulis Sims.	Young shoots and leaves	Both	n	b	13%

	Plantago asiatica L.	Whole plants	Wild	n	b	26%
	Fagopyrum esculentum Moench	Leaves	Wild	n	b	47%
	Persicaria chinensis (L.) H. Gross	Leaves	Wild	n	b	5%
	Polygonum molle D. Don	Leaves	Wild	n	b	13%
	Persicaria nepalensis (Meisn.) Miyabe	Leaves	Wild	n	b	3%
	Polygonum sp.	Leaves	Wild	n	b	3%
Other vitamin A rich fruits	*Ipomoea batatas* (L.) Lam.	Roots	Both	n	b	10%
and vegetables	*Cucurbita maxima* Duchesne	Fruits	Both	n	b	58%
(Fruit vegetables that are	*Sechium edule* (Jacquin) Swartz	Fruits	Both	n	b	89%
orange inside including locally	*Prunus persica* (L.) Batsch	Fruits	Wild	n	ra	3%
available vegetables and	*Carica papaya* L.	Fruits	Cultivated	n	ra	3%
fruits)						
Other fruits and vegetables	*Lycopersicon esculentum* Mill.	Fruits	Both	n	b, ra, ro	55%
(Other locally available	*Solanum melongena* L.	Fruits	Cultivated	n	b	34%
vegetables and fruits	*Cyphomandra betacea* (Cavanilles)	Fruits	Cultivated	n	b	16%
including wild fruits)	Sendtner					
	Solanum anguivi Lam.	Fruits	Both	n	b, ra	10%
	Luffa cylindrica (L.) Roem.	Fruits	Both	n	b	3%
	Cucumis sativus L.	Fruits	Cultivated	n	b, ra	55%
	Momordica balsamina L.	Fruits	Both	n	b, f	3%
	Momordica charantia L.	Fruits	Both	n	b, f	3%
	Allium sativum L.	Bulbs	Cultivated	n	b, ra	42%
	Allium chinense G. Don	Bulbs	Cultivated	n	b, ra	55%
	Allium ascalonicum L.	Bulbs	Cultivated	n	b,ra	31%
	Allium cepa L.	Bulbs	Cultivated	e	b, f, r	3%
	Musa sp.	Young shoots, flowers, fruits	both	n	b	10%
	Bambusa sp.	Young shoots	Wild	n	b, fer	8%
	Stachytarpheta jamaicensis (L.) Vahl	Leaves	Both	n	b	3%
	C*urcuma angustifolia* Roxburgh	Flowers	Wild	n	b	3%
	Zingiber officinale Roscoe	Flowers	Both	n	b	21%
	Elatostema sp.	Leaves	Wild	n	b	3%
	Colocasia esculenta (L.) Schott	Leaf sheaths	Both	n	b	31%
	Actinidia sp.	Fruits	Cultivated	n	ra	3%
	Elaeagnus conferta Roxb.	Fruits	Wild	n	ra	3%
	Phyllanthus emblica L.	Fruits	Both	n	ra	3%

	Artocarpus heterophyllus Lam.	Fruits, seeds	Cultivated	n	b, ra	3%
	Ficus auriculata Lour.	Fruits, leaves	Wild	n	b, ra	3%
	Ficus prostrata (Wall. ex Miq.) Buch.-Ham.*ex* Miq.	Fruits	Wild	n	ra	3%
	Ficus semicordata Buch.-Ham. ex Sm.	Fruits	Wild	n	ra	3%
	Psidium guajava L.	Fruits	Cultivated	n	ra	3%
	Passiflora edulis Sims.	Fruits	Both	n	ra	3%
	Punica granatum L.	Fruits	Cultivated	n	ra	3%
	Citrus limon (L.) Osbeck	Fruits	Cultivated	n	ra	3%
	Citrus maxima (Burm.) Merr.	Fruits	Cultivated	n	ra	3%
Legumes, nuts and seeds (Dried beans, dried peas, lentils, nuts, seeds or foods made from these)	*Vigna umbellate* (Thunb.) Ohwi & H. Ohashi	Seeds	Cultivated	n	b	10%
	Vigna radiata (L.) R. Wilczek	Seeds	Cultivated	n	b, ra	10%
	Vigna sp.	Seeds	Cultivated	n	b	10%
	Dolichos purpureus (L.) Sweet.	Seeds, pods	Both	n	b	5%
	Phaseolus vulgaris L.	Seeds, pods	Cultivated	n	b	42%
	Pisum sativum L.	Seeds	Cultivated	e	b	3%
	Vicia faba L.	Seeds, pods	Cultivated	e	b	5%
	Glycine max (L.) Merr.	Seeds	Cultivated	n	b, fer, ro	23%
	Cajanus cajan (L.) Millsp.	Seeds	Cultivated	e	b	3%
	Parkia timoriana (de Candolle) Merr.	Pods, seeds	Both	n	b, ra	13%

*n = native, e = exotic

**b = boiled, f = fried, fer = fermented, ra = raw, ro = roasted, s = steamed

#Percent of households growing this plant in agroforestry fields