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ORIGINAL ARTICLE

Plant community characteristics and soil status in different land use systems in Dimapur district, Nagaland, India

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Abstract. The main objective of this paper was to evaluate characteristics of plant community and the present status of soil in natural forest, home garden as well as agroforestry and shifting cultivation. We adopted a very well defined standard methodology for assessing various properties of soil. Plant community attributes were determined for different land use systems. The results showed that the importance value index (IVI) was the highest for natural forest, and then for agroforestry system, home garden while shifting cultivation indicated the least value of IVI. The study clearly shows that soil pH, organic matter content, total nitrogen, calcium, magnesium, and phosphorous under the conditions of the land use systems observed differ significantly from those in natural forest. The changes of topsoil properties and plant characteristics are very distinctive in shifting cultivation (jhuming system, i.e. slash-and-burning farming practice in hilly areas). Thus, the results obtained indicate that once natural forest has been removed, the soil-vegetation system is disrupted significantly. The results of this study reveal that shifting cultivation system has negative impact on environment in the region. Furthermore, the land use study carried out based on remote sensing showed that the area of settlement over natural forest has been increasing for last three decades, which results in many environmental problems such as loss of biodiversity, water and soil as well as air pollution.

Key words: plant community characteristics, soil status, land use system, remote sensing, Nagaland

1. Introduction

The mountains provide ecosystem services, including biodiversity and water, that are critical not only for people from mountain communities, but also for those living in the lowlands. Mountainous regions are often vulnerable to natural and anthropogenic pressures. The composite system is very common in the hilly region. The composite system is defined as a system in which radically different farming techniques of cultivation are applied (Rambo 1997, 2007; Crains, Brookfield 2011). FAO/UNEP (1981) estimated that more than 200 million ha of land in closed forest regions are a part of the shifting cultivation cycle, which is the equivalent of about one fifth of tropical closed forest areas and accounts for nearly half of tropical deforestation (Angelsen 1997). At the same time, the area under shifting cultivation increases every year by 1–2% at a global level (Amelung, Diehl 1992) with extreme variations between regions and individual countries. Shifting cultivation has accounts for 70% of total deforestation in Africa, 50% in Asia, and 35% in Tropical America. Many researchers have reported that tropical forest ecosystems store substantial fraction of earth's soil organic carbon and are prone to frequent and severe forest fires. In comparison with unburned soils, burned soils have low concentration of nutrients such as nitrogen and they indicate high concentrations of noncombustible elements such as calcium, potassium, magnesium and phosphorous (Neff et al. 2005). Frequent burning causes significant changes in soil organic carbon. The influence of land cover changes on soil properties has been the focus of numerous studies (Egashira et al. 1986; Quiroga et al. 1999; van Ranst et al. 2002; Wang et al. 2003a; Braimoh, Vlek 2004; Sharma et al. 2004; Celik 2005; Giertz et al. 2005; Islam 2006). Generally, Nagaland's soil is less fertile and more prone to water related erosion (Bhan 2009). Effective soil and water conservation strategies are required to minimize the effect of land cover change on soil properties and to reduce soil erosion problems at different spatial scales, as well as at different organizational levels (Morgan 2005). There is a need to improve soil properties by reducing land cover change with appropriate land management practices. These may contribute to reduce soil degradation and ensure long-term sustainability of farming systems. The present study on the effects of land cover change on topsoil properties could contribute to planning and decision-making processes on decreasing/mitigating soil changes in the study region.

The objective of this study was to evaluate plant community characteristics in the region of Nagaland, and to asses soil properties in different land use systems. The standard taxonomy method was used allowing for the choice of change detection technique and decisions on the data processing requirements. The requirements included geometric/radiometric corrections, data normalization, change enhancement, image classification and accuracy assessment (Lunetta, Elvidge 1998).

2. Materials and Methods

Study area

The geographical area of the district Dimapur comprises 927km^2 at latitude 25°54'45"N and longitude 93°44'30''E. The district has heterogeneous population with the majority of Naga tribes from Nagaland. According to 2011 census the total population of Dimapur is 379,679, with population density 409 persons/km^2. The altitude of the district ranges from 160 to 350 m above sea level. The district is classified into the category of humid subtropical agro-climatic zone (ACZ). Climate is hot and humid in district plains during the summer (reaching maximum 40°C, minimum 10°C, and humidity up to 93%) while the winter months are cool and pleasant. The average annual precipitation in the district is around 1504.7 mm. The status of soil fertility is medium and three major soil types – i.e. loamy sand, sandy clay loam and acidic soils – are present in the district.

Species diversity measurement

Random sampling method was employed for data collection from four different land use systems: natural forest (NF), shifting cultivation (SC), agroforestry (AF), and home garden (HG).

The term 'natural forest' is very controversial because of divergent interests of the stakeholders involved. Natural forest is defined as forest in which naturally immigrant tree species have reproduced spontaneously, i.e. there is no replanting carried out. As per FAO, natural forest has 'naturalness' – a degree of resemblance a given forest has to a forest free from human intervention (http://www.forestfacts.org/l_2/forests_1.htm).

Agroforestry is a collective name for land use systems and technologies in which woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately combined with herbaceous crops and/or animals on the same management unit, either in some form of spatial arrangement or temporal sequence. In agroforestry systems there occur both ecological and economic interactions among different components (Lundgren 1982).

Home gardens under different names (yard gardens, kitchen gardens, etc.) are found in most tropical and subtropical regions of the world (Fernandes, Nair 1986; An-

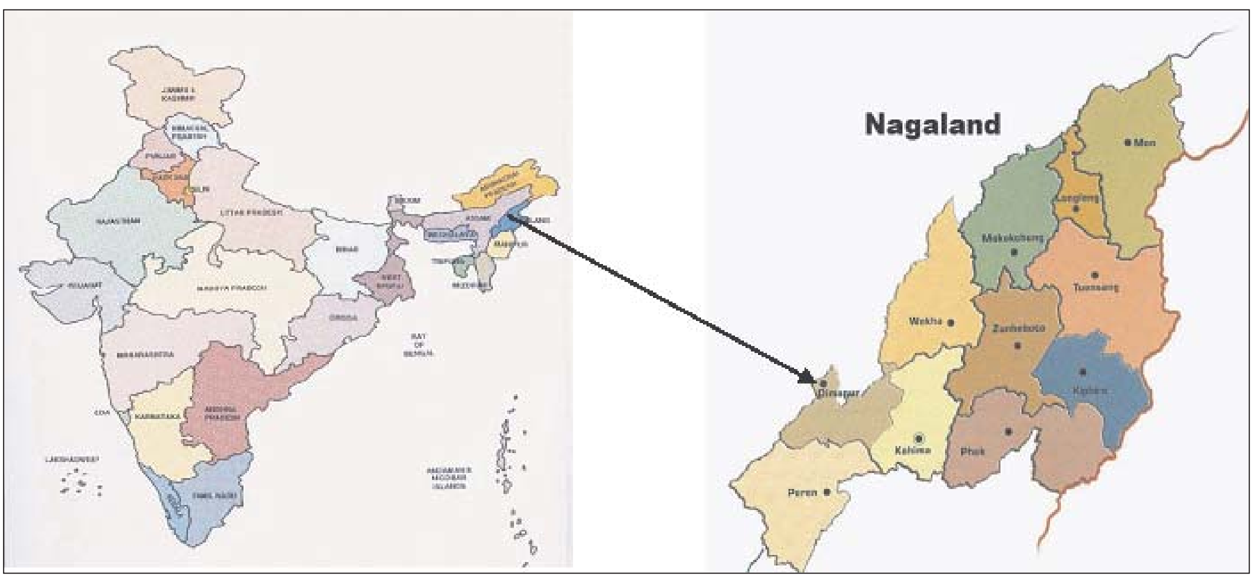

Figure 1. Depiction of Dimapur study area, Nagaland, India

derson 1993a, 1993b; Ortega et al. 1993). It has been estimated that nearly 1000 million people in the tropics live from the produce of 5 million home gardens supported by subsistence agriculture. The home garden is traditionally a very important piece of land (500 to 1500 m^2) for rural households in Southeast Asia. The structure and function of home gardens are similar throughout the region. The home garden can be defined as a farming system, which combines different physical, social and economic functions on the area of land around the family homestead. Within a typical home garden there exist: social areas for meetings, children playgrounds and plant gardens for display along with economic areas for growing food and medicinal plants as well as trees and also for raising animals and fish. Additionally, there are physical areas for living, washing, storage and waste disposal. This is a place for people to live but also to produce a variety of foods and things both for home use and income generation (http://www.fao.org/docrep/V5290E/v5290e02.htm).

Shifting cultivation is describes as an agricultural system, where farming community slashes primary or secondary forests (or second-growth forest) on a predetermined location, burns the slash and cultivates the land for a limited numbers of years. The land is then left to fallow and the farming community moves to the next location to repeat the process till they return back to the starting point. This cyclic rotation from slash to slash forms 'jhum cycle', i.e. – jhuming system of farming.

The sampling was performed after selection of three quadrats (sized 10 × 10 m) which were located along a transect running down through the slope gradient. The data was collected using quadrat counts (numbers of trees occurring in the quadrats were recorded and tree diameter at breast-height (DBH) was measured).

Plant community characteristics

Importance Value Index (*IVI*): The Importance Value Index (*IVI*) has been used to express dominance and ecological succession of plant species. The method implies quantitative parameters such abundance, frequency and basal area of trees determined by relative frequency, relative density and relative dominance. The Important quantitative analysis such as: density, frequency, and abundance of tree species were determined as mentioned by Curtis & McIntosh (1950).

The following formulas were employed for assessment of *IVI*.

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats in which a species occurs}}{\text{Total number of quadrats sampled}} \times 100 \quad (0.1)$$

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats sampled}} \quad (0.2)$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats in which the species occured}} \quad (0.3)$$

The Importance Vegetation Index (Curtis 1959),

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Total density of all species}} \times 100 \quad (0.4)$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100 \quad (0.5)$$

$$\text{Relative Dominance} = \frac{\text{Basal area of a species}}{\text{Basal area of all species}} \times 100 \quad (0.6)$$

$$\text{Basal area} = 0.7854 \times d^2 \ (m^2/ha) \quad (0.7)$$

$$IVI = \text{Relative Density} + \text{Relative Frequency} + \text{Relative Dominance} \quad (0.8)$$

Soil sampling

In all land use systems (NF, SC, AG, HG), observed soil samples were collected using random sampling method. There were sampled 16 quadrats seized 10 × 10 m. From each quadrat three replicates of the soil layer of

10 cm deep were taken and mixed thoroughly for further analyses of pooled samples. In total twelve soil samples were collected in January 2011. The soil samples were air dried and stored for physico-chemical analyses.

Chemical analysis of soil

Chemical analyses of soil properties included determination of: soil pH, total nitrogen (N), total organic carbon content (SOC), exchangeable potassium (K) and available phosphorus (P).

Soil pH was evaluated using an electronic digital pH meter. Soil organic carbon (SOC) was assessed following Walkley & Black's rapid dichromate oxidation method (1934). Percentage organic C content was calculated using the following formula:

$$\text{Organic Carbon (\%)} = \frac{10(B-T)}{B} \times 0.003 \times \frac{100}{S} \qquad (0.9)$$

Where: B = volume [ml] of ferrous ammonium sulphate solution for blank titration, T= volume [ml] of ferrous ammonium sulphate solution needed for soil sample, S = weight [g] of soil.

The total soil nitrogen (N) was assessed with Kjeldahl's digestion method. Percentage nitrogen content was calculated using the following formula:

$$\text{Total Nitrogen} = \frac{14 \times \text{Normality of Acid} \times \text{Titrant Value}}{\text{Sample Weight} \times 100} \qquad (0.10)$$

Exchangeable potassium was determined following the method suggested by Ghosh et al. (1983). The formula for estimation of soil potassium (K) is given below:

$$\text{Exchangeable Potassium (mg of potassium per gm of soil)} = \frac{A \times V}{W \times 100} \qquad (0.11)$$

Where: A= K content in standard soil extract [mg/l], V= volume of soil extract [ml], W= weight of air dried soil taken for extraction [g].

Available phosphorus content was determined using Olsen's method. The formula used for calculation of P was:

$$\text{Olsen's Phosphorous (kg/ha)} = \frac{R \times V/v \times 1/S \times 2.24 \times 10^6}{10^6} \qquad (0.12)$$

$$P = R \times (50 \times 5) \times 1/2.5 \times 2.24 = R \times 8.96 \qquad (0.13)$$

Where: V = total volume of extractant (50 ml), v = volume of aliquot taken for analysis (5 ml), S = weight of soil (2.5g) and R = P in standard curve aliquot [μg].

3. Results and discussion

Land use and land cover change (LULCC)

The acquired satellite images obtained in the years 1990, 2000 and 2010 were classified using ERDAS 9.1 and ArcGIS 9.3 softwares. The different types of land cover/land use in the classified image are presented in Figures 2 a, b & c. In 1990, the majority of land was covered with dense forests. Data on land use in 2000 and 2010 show increased settlement area and decreased forest area. There was almost no change observed in the area of water bodies – rivers and tributaries (Table 1).

Table 1. Land use areas of different classes

Land use type	Area 2010 (in sq km)	Area 2000 (in sq km)	Area 1990 (in sq km)
Settlement	46.106	38	32.022
River	9.93	9.93	9.93
Dense Forest	591.71	615.474	628.06
Open Forest	201.38	191.372	195.829
Water Body	1.022	0.246	0.234
Swampy	0.603	0.703	0
Home garden	76.498	71.498	60.976
Total Area	927.249	927.223	927.051

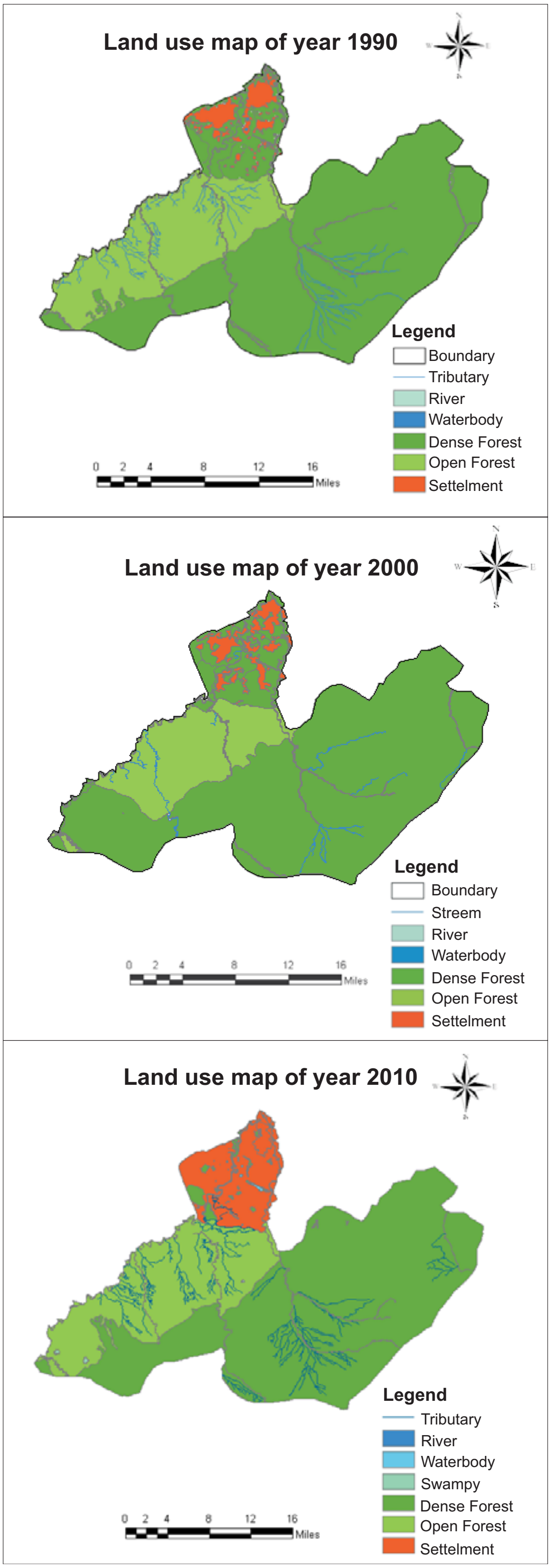

Figure 2 (a) Land use map of the years 1990 (a), 2000 (b), and 2010 (c) (derived from the satellite image after classification)

Soil nutrients

The total content of nitrogen was high in natural forest (NF) when compared with other land use systems observed. This may be due deposition of more dead organic matter and litter or else the presence of nitrogen fixing soil bacteria in NF. It was also observed that nitrogen content was medium in SC and AF systems because of litter deposition and presence of soil organisms (SC), and nitrogen fixing crops/trees (AF). Nitrogen content was lower in HG system because of different crops and trees cultivated there. Potassium content was higher in NF when compared to other systems observed, which means that nutrient content in NF was not disturbed. Potassium content in AF, HG and SC was comparatively lower than NF. This may be due to leaching of potassium from soil during rainy days. Low potassium content in soil might be due to high potassium intake by crops grown in the field. Phosphorous content was higher in NF, however in general, soil phosphorous content in all land use systems observed was nearly at the same level, opposite to the content of other nutrients. This shows that the land use systems such as AF, SC, and HG do not much affect phosphorous content. Soil pH values in AF, HG and SC, systems were similar. On the other hand, soil pH in NF was higher than that in other three land use systems. This might have been a result of high soil moisture, which favored microorganisms enhancing organic decomposition followed by lowered soil acidity. Low pH observed in AF, HG and SC soils was caused by lesser canopy than in NF, which resulted in lower soil moisture and microbial activity leading to higher soil acidity. Soil organic carbon content was fairly high in NF when compared with AF, SC and HG. This may be due to deposition of more dead organic matter and litter in NF. Furthermore, it was also observed that organic C content was lower in HG, which must have been due to

Table 2. Contents of nitrogen (N), potassium (K), phosphorous (P) (kg/ha), organic carbon $C_{Organic}$ (%) and pH values in soil collected from different land use systems.

Land use system	Nitrogen (kg/ha)	Potassium (kg/ha)	Phosphorous (kg/ha)	Organic Carbon (%)	pH
AF	297.6	167.2	108.5	2.1	4.4
HG	165.8	156.7	107.5	0.8	4.1
SF	324.4	169.3	92.8	1.6	4.4
NF	476.5	323.5	117.4	3.2	6.3
Average	316.07	204.17	106.55	1.92	4.8
Max	476.5	323.5	117.4	3.2	6.3
Min	165.8	156.7	92.8	0.8	4.1
Std Deviation	127.45	79.74	10.18	1.01	1.01

less litter deposition. However, contents of organic C in SC and AF were almost same, and this might be due to deposition of more litter. Especially, for SC deposition of fresh litter might have been very high because its organic carbon content is regenerating at high rate.

The available total nitrogen in the four systems shows following trend i.e. increasing from HG through AF, SC to NF respectively in the study region. However, Figure 3 clearly shows that the highest N content was observed in NF and the lowest in H, where as remaining two systems indicated similar N concentration. This may

Table 3. Importance value index, Density (ind/ha), Frequency (%), Basal area (m^2/ha) and Importance Value Index (IVI) in AF, HG, SC and NF

Sl. No	Scientific name	Density (ind/ha)	Frequency (%)	Basal area (m^2/ha)	*IVI*
	Agro-forestry System				
1	*Zanthoxylum rhesta*	66.66	100	6.06	67.02
2	*Alnus nepalensis*	66.66	100	5.57	65.21
3	*Mangifera indica*	44.44	100	3.39	42.41
4	*Parkia roxburghii*	22.22	66.66	3.89	35.44
5	*Artocarpus chaplasa*	11.11	33.33	5.56	30.93
6	*Mechelia champaca*	22.22	66.66	1.30	25.98
7	*Oroxylum indium*	11.11	66.66	0.82	19.87
8	*Streculia urens*	11.11	33.33	0.68	13.10
	Total	255.53	566.64	27.27	299,96
	Home garden				
1	*Areca catechu*	200	100	7.25	87.30
2	*Termanalia myriocarpa*	44.44	66.66	8.92	55.61
3	*Carica papaya*	88.88	100	3.19	49.09
4	*Mangifera indica*	55.55	100	3.39	43.03
5	*Litchi chinensis*	66.66	66.66	1.33	31.21
6	*Psidium guajava*	22.22	66.66	1.58	23.10
7	*Citrus lemonata*	11.11	33.33	0.55	10.63
	Total	488.86	533.31	26.21	299,97
	Shifting Cultivation				
1	*Albizza chinensis*	44.44	100	5.00	107.64
2	*Alnus nepalensis*	44.44	100	1.86	75.60
3	*Schima wallichi*	44.44	66.66	2.34	70.53
4	*Caryota urens*	33.33	66.66	0.61	46.28
	Total	166.65	333.32	9.81	300
	Natural Forest				
1	*Spondias macrophylla*	44.44	66.66	5.39	35.11
2	*Gmelina indica*	22.22	33.33	14.15	29.83
3	*Zanthoxylum rhusta*	33.33	33.33	10.01	29.39
4	*Alstonia scholaris*	11.11	33.33	17.23	29.13
5	*Oroxylum indicum*	33.33	66.66	0.68	26.06
6	*Lagerstromia parviflora*	22.22	33.33	6.51	21.65
7	*Schima wallichii*	33.33	33.33	2.05	20.86
8	*Shorea assamica*	11.11	33.33	8.87	20.17
9	*Dipterocarpus myriocarpa*	11.11	33.33	8.38	19.65
10	*Tetrameles nudiflora*	11.11	33.33	7.23	18.41
11	*Aqualaria agollocha*	22.22	33.33	3.16	18.05
12	*Artocarpus chaplasa*	11.11	33.33	6.16	17.26
13	*Callicarpa rubella*	11.11	33.33	3.46	14.37
	Total	277.75	499.95	93.28	300

be generally due to climatic factors, topography, types of vegetation and crops/trees planted. The highest potassium concentration was found in NF, while other land use systems indicated similar K contents. Higher K present in NF soil is a sign of no disturbance in the soil structure. Low potassium content in the case of SF, AF and HG might be due to leaching from soil or else because of high K uptake by cultivated crops and trees. Phosphorous present in the different land used systems analyzed was almost at the same level, even though higher in NF and lower in SF. Phosphorous loss might have been due to leaching during rainfalls or connected to the terrain structure. Soil organic carbon (%) in the region was increasing from HG through SC and AF to NF. This shows that litter and organic matter deposition and decomposition were lesser in the three land use systems in comparison with NF.

Tree diversity

In total 48 plant species were identified and recorded in NF, AF, HG and SC areas. The species of trees are listed in Table 3.

In the Dimapur AF system the most dominant species was *Zanthoxylum rhesta* (IVI=67.02). Other co-dominant species were: *Alnus nepalensis (IVI=65.21)* and *Mangifera indica* (IVI=42.41). *Areca catechu* was most dominant in HG *(IVI=87.30)*. Other co-dominant species in home garden system were: *Termanalia myriocarpa (IVI=55.61)*, *Carica papaya (IVI=49.09)* and *Mangifera indica (IVI=43.03)*. In SC, *Albizza chinensis* was most dominant *(IVI=107.64)*. Other co-dominant species in shifting cultivation were: *Alnus nepalensis (IVI=75.60) Schima wallichi (IVI=70.53)*. In NF, *Spondias macrophylla* was most dominant *(IVI=35.11)*. Other co-dominant species in natural forest were: *Gmelina indica (IVI=29.83), Zanthoxylum rhusta (IVI=29.39) Alstonia scholaris (IVI=29.13) and Oroxylum indicum (IVI=26.06*).

Tree species prevailing in the agroforestry system (*Z. rhesta, A. nepalensis* and *M. indica*) provide villagers for enough fuel wood and also ensure good fruit and crop productivity of AF system in the district. *The villagers use A. nepalensis trees* abundantly in agroforestry systems. Tree cultivation increases soil fertility through fixing nitrogen, which improves yielding of agricultural crops

In general, tree species such as: *A. catechu, T. myriocarpa, C. papaya, M. indica* occurred more profusely than other tree species. This is mainly due to climatic conditions in the district, but also caused by the choice of the tree species for growing by land owners. *T. myriocarpa* is planted for making household furniture and the species such as *C. papaya* and *M.indica* are grown for fruits for domestic use as well as to share with neighbors.

Table 4. Average density of species (ind/ha) and average basal area (m^2/ha) in different land use systems (AF, HG, NF, SC)

Land use systems	Density (ind/ha)	Total basal area (m^2/ha)
NF	277.77	93.34
SC	166.66	9.82
HG	488.88	26.24
AF	255.55	27.33

Tree species such as: *A. chinensis, A. nepalensis* and *S. wallichi* are dominant in shifting cultivation. The reason for that might be the fact that trees of these species are left standing by the farmer without slashing/cutting down during jhuming. Besides, the above tree species compete with other species for sunlight and soil nutrients, and as a result suppress development of trees of other species.

Tree species such as: *S. macrophylla, G. indica, Z. rhusta, A. scholaris, O. indicum* are dominant in natural forest in Dimapur region. This indicates that these species are more successful in competition for light, nutrients and water than other tree species occurring in the area. This might be connected to their structural features such as huge canopy density. Also, region topography and climate, might be favorable for the above tree species.

Average tree density in HG – 488 (ind/ha) was higher than in other three land use systems observed, which indicates high tree diversity in home gardens. On the other hand, tree density 277 (ind/ha) and 255 (ind/ha) in NF and AF systems, respectively, was also quite high (Table 4). This shows that tree diversity is well maintained in the latter two land use forms when compared with SC system.

The total basal area was highest in natural forest – 93.34 (m^2/ha). This means that NF diversity is very rich and not disturbed. The lowest average basal area was observed in SC – 9.82 (m^2/ha). This result indicates that the soil properties and tree diversity have been disturbed to a great extent in SC land use system. Average basal areas observed in HG and AF systems show that these land use systems are ecologically and environmentally sound.

4. Suggestions

Shifting cultivation is a traditional practice, which has been carried out all around the world for centuries. Nonetheless, there is a need to reduce or mitigate its negative impacts by adopting methodical techniques such as terracing, growing cover crops, green manuring, mulching, establishing plantations of tree saplings and applying crop rotation. People should be encouraged to go for shifting cultivation alternatives, such as agroforestry systems which are not only more productive but also more ecology and environment friendly. Awareness programs are required to inform local communities about impacts of shifting cultivation on environment and benefits of different land use systems. People should be encouraged to utilize fallow lands in their regions for gardening. There is a need for new policies on agricultural activities in the hilly areas. This requires input from all the stakeholders involved.

5. Conclusion

Trees have had a great influence on shaping ecology of our planet and determining present arrangements of life on earth. A slight deficiency in any nutrient, in soil may result in visible symptoms in the plant, being either changes of coloration or defects in growth patterns. In the present study tree diversity in different land use system observed in the Dimapur district of Nagaland was high in natural forest and lower in agroforestry, shifting cultivation and home garden systems. Tree diversity of SC system was considerably low, which clearly suggests that shifting cultivation is a destructive type of land use in Nagaland. What is more, the study on soil nutrients in different land use systems showed that soil fertility was deteriorating in current land use systems, especially in shifting cultivation due to narrowing down the time period of SC cycle. Soil nutrient contents in agroforestry and home garden systems were high; this might be due to the nutrient management practiced.

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