Agro-Ecosystem Sustainability in a Forest dependent Tribal Villages in West Karbi-Anglong District of Assam

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Abstract

The present study was carried out in West Karbi-Anglong district inhabited by Karbi tribes in Assam to assess present state of socio-economic components of village and efficiency and viability of production systems at the current level of natural resource dependency and to find out the linkage between human community and forest ecosystem. The study area comprises of ten villages where human population varies from 32 to 112 in uphill villages and 87 to 132 in foothill villages. The cultivated area ranges from 6.26% to 12.23% of the total village geographical area with per capita cultivated area 0.112 to 0.429 ha.. The quality of forest has been affected due to absolute dependency on resources which calls for taking appropriate step to enhance forest productivity. All villages depend on rain fed agriculture, natural stream water is used to cultivate paddy in valleys, shifting cultivation practiced in uphill areas, mid hill orchards below the Hamren area and home garden adjoining habitation. Cereals, pulses and vegetables are grown together in Hamren areas. Maize is a major cereal as staple food grown in uphill villages. The village productivity of maize, legumes and paddy is much lower than other settled agriculture areas of the state. The home garden areas are grown with vegetables and cereals especially for domestic use. However, vegetables like Tomato, Brinjal, Bin, Sweet Potato, Chilly from foothill villages are marketed. Home garden provides variety of requirements to the tribal community round the year. The production of agriculture sub-system is not sufficient to meet the food requirement of villages and rice distributed to villagers meet this gap. However, crops grown as horticulture products (Pine apple, Banana, Orange, peach) and a few Millet crops in the uphill villages like minor Millets, are exported to markets for earning money as these are only assets recorded as high energy valued products. Millet Mission (MM) may need to provide interventions to these villages with modern approach to increase Millet productivity including improvements in seed quality and health condition of the tribal community. To ensure sustainability of the traditional cultivation and livelihood system, involving the people of these villages in forest-based activities other than agriculture will lead to protecting the indigenous biodiversity of this region.

Key Words: Livelihood, Agriculture, Millet, Forest, Hamren, West Karbi-Anglong, cultivation, Sustainability, Tribal

Introduction

The people living in surroundings of the natural protected areas depend on these Ecosystems for their livelihood and ecosystem services including water, fuel, fodder and other forest produce. The people inhabiting in these zones and surroundings are experiencing decline in resource value (Kothari 1996), so their access to various components of natural resources is becoming a limiting factor to survive. The tribal villages near forests mainly perform their activities by recycling resources within the system (Rabindranath etal., 1981; Nishankaand Misra, 1990; Nayak et al., 1993;Mishra and Ramkrishnan, 1982). The traditional practices of ethnic human population which was a sustainable way of living with ecosystem are being codified due to resource depletion and imbibing modern way of livings. This defeats the goals of biodiversity conservation in natural forest ecosystems as demand driven society will cause depletion and extinction of living natural species. Therefore, changing consumption and agricultural cultivation patterns now demands integrating protected area management with development projectsby ensuring an effective participation of people in the management process (McNeely and Miller 1984, Maikhuri*et al*. 1998, Rao *et al*. 2000, 2003b). The tribal people living in and around forest areasare to adapt themselves to environmental pressure associated with market driven natural resource exploitation (Grunbuhel *et al*. 2003). The material and energy extracted from the environment are processed which are the basis of a certain mode of production and its related consumption patterns. The socio-economic activity in forest dependent human settlements need to be regulated in view of depletion of resources and danger of vanishing the diversity due to pressing livelihood needs of these groups to maintain carrying capacity driven material and energy flow between their settlements and its environment. Therefore, these interactions must address the sustainable way of the functioning of natural ecosystems (Fisher-Kowalski and Haberl 1993). The study of interrelations between a tribal village settlement and its natural environment in West Karbi-Anglong (Assam) requires an interdisciplinary approach which is important for sustainable management. This is because social systems reproduce themselves not only culturally and socially, but also physically by constantly exchanging energy and material with their natural environment and with other socio-economic systems.

Traditional agriculture generally is practiced in organic way and has inbuilt mechanism to optimize their use and their subsistence life styles. We can assess the subsistence economy and market and lifestyle changes by input-output analysis in traditional forest dependent villages are in understanding the village ecosystem functions (Azeez *et al*. 1992, Nautiyal 1998, Maikhuri et al. 2000). The present study was carried out in Karbi-Anglong hills inhabited by Karbi tribes in Odisha to assess socio-economic components of village and efficiency of production systems and viability at the current level of natural resource dependency and to find out the linkage between human community and forest ecosystem and

suggest sustainable model. Thus, this case study aims at gathering information on agro-ecosystem practices functioning around West Karbi-Anglong forests and to suggest how conservation objectives can be achieved making village agro ecosystem practices sync with ecological requirements.

Study area and Environment

The district with dense tropical forest covered hills and plains is situated in the latitude 25°33´N to 26º09´N and longitude 92º08´E to 93º04´E. Due to variation in the topography, this hill zone experiences different climates in different parts. Even though, the district is dotted with hills, a few of which can be categorized into Mountain. Among them, the highest is the Singhason Peak which is at about 1360 metres above the sea level. The district is bounded by Hojai district on the east and on the north, Meghalaya state and Morigaon district on the west, Nagaon and Dima Hasao district and Nagaland state on the south. West Karbi Anglong is a part of the Indo-Burma biodiversity hot zone; it includes the oriental zoological region. There is no exhaustive report to describe the total floral and faunal diversity of West Karbi-Anglong district.

The altitudinal variation is from 400m mean sea level (msl) to 1516m msl which is responsible for varied vegetation, higher rainfall, and cooler micro-climate with perennial streams. Karbi hill range is an extensive area with degraded Sal forest interrupted by practices of shifting cultivation near the habitation areas. Inhabitants in the range are Karbi tribe namely a primitive tribal group settled near perennial streamsin high altitude areas (600-700m msl). In the region microclimate effect is clearly revealed with cooler atmosphere, more rainfall than adjoining area and rich biodiversity. The settlements are connected by difficult terrain footpaths. All weather roads is a recent development to peripheral villages otherwise the vast tract of land is almost virgin. Shifting cultivation provides food and fodder to the ecosystem people and forest provide additional support with tubers, fruits, leafy vegetables besides fuel wood, housing materials, agriculture implement and grazing land. Although West Karbi Hill Ranges extend in four blocks, the Rongkhang block is selected for the present study because the villages are located at approachable distance. Four village settlements at higher elevation inside Singhason hills are selected for the study of Agro-ecosystems. Another four village settlements selected at the foot hill of Singhason out of which two are closer to market place (urban area) and two are little

away from urban area. The toposheet map of the Singhason shows hilly terrain throughout the forest cover and settlements or habitations without road connectivity, far away from each other.

List 1.Village settlements of hilly terrain

Village inside Singhason Hill Forest at higher altitude.	1. Agra kunchi 2. Ahom Buroi 3. Akelal 4. Akelal-2
Villages outside Singhason at the foot hills, away from market place	5. Ambuda 6. Amguri
Villages outside Singhason at the foot hills, nearer to market place	7. Am-ih 8. Amlet

Singhason hill ranges experiences monsoon climate, from mid-May to mid-October which is more than normal monsoon period of three months. The average rainfall of the district varies from 1061.66 mm to 1491.4 mm over 5 years i.e. 2019 to 2023. The tropical monsoon accounts for mainly total annual rainfall of 1100-1500 mm with concentration in rainy season (July to September). The temperature variation of the district ranges between 6.5°C and 30°C (data average 2019 to 2023) and the relative humidity varies from 40% (March) to 85% (July). Further details on Temperature and humidity changes on monthly variations in the year is available in Upadhyay et al. (2022). The rainfall spreading over five months creates a micro-climate in the area which is experienced by the rich bio-diversity vegetation. Most of the streams are perennial in nature and the inhabitants use the water for domestic purpose and irrigation. The forest vegetation is of miscellaneous nature with intermittent Sal forest with its associates. The villages in and around Singhason Hill Range derive their livelihood from forest resources. The practice and traditional agriculture in the vicinity is prehistoric. The intense inter-dependency of Agro-ecosystem and Forest eco-system has led to both ecological and economic erosion in these ecosystems. Studies of eco-system linkages and socio-cultural changes are essential to develop strategy to arrest further degradation of ecosystem and suggest priority sectors for improvement.

Methodology of Study

The socio-economic data and ecological parameters of the eight villages were collected through questionnaire-cum-schedule method following Reddy (1981), Singh and Singh (1992), Nayak et al. (1993) and Sahoo (1993). Four villages were situated inside Singhason Hill Forest at higher altitude, two villages at the foot hills, away from market place and two villages at the foot hills, nearer to market place. The boundaries of the villages were defined with the help of the State Revenue Map. The sampled villages were visited regularly for collection of data depending on the availability of the inhabitants. The survey information was collected by interviewing the family head. Sample weighing of humans, animals and

materials was done in the field. The data collection continued for reverification in the selectedvillages from year 2019 to 2023 by repeated visits and interview as needed.

The human population is calculated from the total family members of the villages. Literacy rate was determined by interviewing the head of the family. The Human Population and Literacy survey was carried out in 2019 as preliminary database of eight villages. For Socio- Economic Structure, the questionnaire forms are filled up by getting information from the family head about their occupation, source of income, materials used in day to day life and construction of houses, cultivation and agro-products market and sale of available surplus product, after self-use, etc. Land Ownership and Cropping Pattern were collected in respect of each of the family in the tribal villages. Shifting cultivation is commonly practised in hilly track, for which the information was collected in details by field visit. The inputs and outputs for different crops were recorded including home garden and valley cultivation and horticulture products which support the economics of most of the families are Orange, Pine apple, Banana, Litchi, etc. The crop residues used as soil fertilizer or fuel wood is also recorded. The above ground biomass of crops grown in shifting cultivation area, home garden and valley area were estimated in the field at the time of harvest. The individual crops raised by the villagers was sample measured at the harvest time and total production of biomass of each family was recorded. The individual biomass production was added to get the total village biomass production (t ha^{-1}). The productivity was calculated for the total production of the village crop wise and divided over the cultivated area to get average productivity of the village. Information on Marketing and Marketable Products from these villages was also collected for the study. The surplus agricultural products are normally sold in the nearest weekly market (Chatikona). The market demand for different forest produce is also provided by the villagers on weekly basis or as and when required. This provides economic support and eligibility to purchase his family requirement from the market. The information of sale and purchase of different commodities by villagers are recorded. The food consumption was calculated depending on the total production for Agriculture, Forest animal husbandry etc. excluding the products sold in weekly market or village itself as surplus only. The food grain, vegetable etc. purchased from weekly market or Public Distribution System (PDS) are added to the quantity consumed. In agriculture the crops are produced in different seasons. The grains and residues were also sampled to assess total production. The domestic animals like cattle, goat etc. graze in the adjoining forest. No stall feed is provided. The crop residue left in the field was collected in a sample area and weighed to assess the total residue left in the fields.

Results

The details of geographical area of the eight villages under study are given in the components under housing and cultivation (Home garden, shifting cultivation and valley cultivation). The villages are widely separated from each other and boundaries are demarcated by the hilly topography and vegetation. For shifting cultivation and collection of minor forest produce, the forests beyond the village boundary are used by villagers. Per capita cultivated area varies from 0.98 ha. (Patlamba) to 0.332 ha. (D.Kumbharabadi). Forest area is utilized for shifting cultivation and home garden. Paddy cultivation is practiced in one upper hill village (Rhodanga) and three-foot hill villages Shifting cultivation is prominent in four villages located in upper hill area (Human Population dynamics in villages indicate that average family size varies from 3.8 to 5.2 The literacy rate varies widely from 4.8% to 72% in D. Kumbharbadi. Elder persons above age group of above 40 years are totally illiterate in uphill villages, however the adults with age group 25-30yrs have some education.The topography plays a major role in the land use with easy gradient slopes with soil cover are mostly used for raising crops under the shifting cultivation. It is always a poly culture locally known as “Dongar” cultivation of all cereals, pulses, oil seeds type complex cropping traditional practice with ecological and economic advantages in rain-fed condition.Other land use category is the valley area cultivation known as “Gudia” or “Padar” which is mostly used for Ginger and Turmeric and some fruit plants surrounding the field or house. The land is mostly used for different cash crops like Bananas, Orange, Mango, Litchi, Jackfruit etc. The third land use category cultivation is the Nala-beds / aquatic areas with perennial stream flow of water mostly used for paddy. The villages situated at low elevation in the periphery of Niyamgiri practice paddy cultivation using stream water in very small patches. High rainfall in these areas sometimeslead to speedy flow in Nala-beds washing all crops. Thus, three major categories of land are available for agricultural use. The home-stead village areasare very small with compact houses in rows facing each other with common place. The aquatic area is only streams which are mostly perennialand major common property resource (CPR) is forest land and the uncultivated area.

Agro-Ecosystem and Village Ecosystem Function

Cropping Pattern

The cropping pattern is regulated by nature as per the annual seasonal variation of rainfall and temperature. Almost all cultivation is rain fed in nature and accordingly land preparation starts in summer, cultural operation continues in rain and harvest of crop starts at beginning of winter. In these three seasons, about 9 months a year, people remain busy in the field. The cropping pattern of different

crops is detailed in table-1 which is almost similar for all villages. The uphill villages cultivate different types of cereals which is unique for this locality.

Table 1. Cropping Pattern and their seasonal distribution in Singhason Hill study area

Crop		Sowing season	Harvest season
CEREALS			
1	Paddy (*Oryza sativa*)	Jun -July	Nov - Dec
2	Maize (*Zea mays*)	May - June	Sept - Oct
3	Finger Millet (*Eleusinecorocana*)MANDIA	Jun -July	Sept - Oct
4	Pearl Millet (*Pennesetumtyphoides*)GHANTIA	Jun -July	Nov - Dec
5	Common Millet (*Panicumpaludosum*)KANGU	May - June	Nov - Dec
6	Barnyard Millet (*Echinochloaconlonum*)KOSHALA	Jun -July	Nov - Dec
LEGUME			
1	Red Gram (*Cajanuscajan*) KANDULA	Jun -July	Jan - Feb
2	Jhudanga (*Vignaunguiculata*)	Jun -July	Oct - Nov
3	Katinga (*Vigna*sps)	Jun -July	Sept - Oct
OILSEED			
1	Mustard	Oct-Nov	Feb - March
2	Niger (*Guizotiaobyssinica*)	Oct-Nov	Feb - March
3	Rasi (*Sesamumindicum*)	Sept - Oct	Feb - March
	VEGETABLES		
1	Brinjal (*Solanum melanogena*)	Aug -Sept	Nov - Dec
2	Tomato (*Lycopersium esculentum*)	Aug -Sept	Nov - Dec
3	Lady Finger (*Hibiscus esculentus*)	Aug -Sept	Nov - Dec
4	Simba (*Dolichus*sp)	Aug -Sept	Nov - Dec
	CASH CROPS		
1	Cotton (*Gossypium hirsutum*)	June - July	Nov - Dec
2	Tobacco (*Nicotiana tabacum*)	June - July	Nov - Dec
3	Turmeric (*Curcuma longa*)	April -May	Jan - Feb
4	Ginger (*Zingiber officinale*)	April -May	Nov - Dec
	FRUITS		
1	Jack Fruit (*Artocarpus integrefolia*)		Green (Feb - March) June-July
2	Mango (*Mangifera indica*)		May-June
3	Pine Apple (*Ananas sativa*)		June-July
4	Orange (*Citrus sinensis*)		Sept-Oct

Area Under Cultivation and crop yield

The Agro ecosystem productivity of these villages can be grouped into four categories on the basis of the production of different crops and their geographical location viz.,shifting cultivation, Mid-hill orchards,

Home-garden, and Valley cultivation areas. Since all the villages are more or less associated with hills, the classification is based on the topography. Area of different cropsis shownin Table 2.The primary productivity (yield) of these villages depends mostly on natural factors. The biomass and productivity (yield) of crops in the villages were assessed for various category of laduses. Productivity refers to the production per unit area over time and the biomass refers to the weight of organic matter produced in the crop. Present study involves the estimation of biomass and net primary production (yield) of these tribal village Agro-ecosystem .Agricultural Crop Pro ductivity of the each of Village Eco system for the year 2021-22 is given in Table 2**.**

Table 2. Area Under Cultivation of Different Crops (ha) in the Villages Under Study during 2022-23

	A1	A2	A3	A4	A5	A6	A7	A8
Shifting cultivation (Up Hill)								
Finger Millet (Mandia)	5.465	13.522	19.149	14.21	9.028	4.129	7.854	7.328
Pearl Millet (Ghantia)	5.465	13.522	19.149	14.21	-	-	-	-
Common Millet (Kangu)	5.465	13.522	19.149	14.21	-	-	-	-
Barnyard Millet (Koshala	5.465	13.522	19.149	14.21	-	-	-	-
Redgram(Kandula)	5.465	13.522	19.149	14.21	-	-	-	-
Jhudang	5.465	13.522	19.149	14.21	-	-	-	-
Kating	5.465	13.522	19.149	14.21	-	-	-	-
Mustard seed	5.465	13.522	19.149	14.21	-	-	-	-
Niger	5.465	13.522	19.149	14.21	-	-	-	-
Rasi	5.465	13.522	19.149	14.21	-	-	-	-
Mid Hill (Orchard)								
Zinger	0.1	10.1	10.9	6.8	-	-	-	-
Turmeric	1.0	11.56	7.20	4.40	-	-	-	-
Orange	0.00	2.13	1.05	1.0	-	-	-	-
Mango	1.60	3.24	16.92	7.8	-	-	-	-
Pine Apple	1.6	3.24	16.92	7.81	-	-	-	-
Jack Fruit	0.4	0.80	0.61	0.40	0.10	0.04	0.10	0.06
Home Garden								
Vegetables	0.61	5.18	3.24	3.04	8.06	3.4	7.11	15.2
Valley								
Paddy	-	7.22	-	-	10.9	3.46	13.1	-
Maize	0.566	1.235	10.809	9.514	8.016	4.574	4.777	0.554
NB-Cereals, legumes and oilseeds grown in same land								
NB-Mango and Pine apple are grown in same land								
Note: A1- Agra kunchi , A2- Ahom Buroi, A3- Akelal, ,A4—Ambuda A5 Amguri , A6-- Am-ih , A7-. Amlet, A8- Akelal-2								

Shifting Cultivation

Shifting cultivation commonly known as jhum cultivation is a prevalent practice in hilly forest areas, mostly an adopted agriculture system by the tribal community. The areas of individual household's jhum cultivation were ascertained by sample field verification of each village. The village-wise area under different crops is given in Table-2. Jhum cultivation is prominent in uphill villages, whereas it is rarely practised in foothill villages. Here also, the Karbi Tribe practice jumia cultivation in uphill areas for the

production of different agriculture crops. The cereals, pulses and oil seeds are grown in mixed cultivation practice to meet the food requirement of the family. The common crops are Finger Millet (Mandia), Pearl Millet (Ghantia), Common Millet (Kangu), Barnyard Millet (Koshala), Redgram (Kandula), Jhudang, Kating, Caster seed, Niger and Rasi. Higher slope with soil cover areas are selected for the Podu cultivation. Trees including undergrowth are completely cut and burn during summer. Small stumps are uprooted living the big stumps to naturally decay. This process is carried out during February to April i.e. before monsoon. The families occupy different patches for shifting cultivation which is rotated in a three-year cycle. The occupation of shifting cultivation area is almost hereditary, though it has no records in Government revenue or forest department. The extent of cultivation area is taken as per the working members of the family. Sowing is done after first few showers. Pulses like Redgram, Jhudang, Katingand oilseeds of mustard are sown in lines at regular interval, whereas other seeds of cereals and oilseeds are broadcasted over the entire area. The watch and ward provision from the wild animals are made by preparing a small hut nearby which continues up to the crop harvest. The cropping pattern and their seasonal distribution is detailed in Table 1 and photographs of plants, fruits seeds of crops grown by villagers are shown in Picture 1 to Picture 4.

Picture **1.**Pearl Millet (GHANTIA)

Picture **2.**Common Millet (KANGU)

Picture **3.**Finger Millet (MANDIA)

Picture **4.**Barnyard Millet (KOSHALA)

Mid-Hill Cultivation (Orchards)

The forest area below the Jhum cultivation area and above the village habitation is cultivated and used for developing different orchards like; pineapple, Orange, Jackfruits, Zinger and Turmeric. All these crops are mostly induced practice with the support of International Fund for Agricultural Development (IFAD) and other Government Schemes. Annual maintenance of these crops is done by cutting of weed growth and providing mulching to the trees. Zinger is annually harvested and planted, whereas turmeric is harvested in 2nd or 3rd year and planted again during summer. All the crops are cash crop which provide good annual income to the uphill villagers. These orchards and under- crops are rarely practised in foothill villages.

Picture 5..Pineapple Cultivation at Mid-hill Orchards

Picture 6. Jackfruit in Niyamgiri Forest

Picture 7.Mid hill Orchard

Home-Garden

The area around the house premises is grown with vegetables and cereals especially for domestic use. Maize is a major cereal for staple food grown in rainy season in uphill villages. The production of vegetables in commercial scale is mostly practised by foothill villagers and marketed in the nearby weekly market of Hamren Home garden provides variety of requirements to the tribal community round the year. Among vegetables,Tomato, Brinjal, Bin, Sweet Potato, Chilly are commonly practiced. Apart

from these, Papayas, Pumpkin, Bitter-Gourd are also cultivated. Tomato and Brinjal are major cash crops for the foothill villagers. The area used for home garden was recorded household-wise and presented village-wise in Table 2. These crops are mostly grown during rainy season. The area per village varies from 0.61 ha to 15.2 ha across different villages.

Valley Cultivation

Valley cultivation is taken up near the available natural water source i.e. Streams and Nalas flowing below the habitations. It is mostly the paddy crop practiced in one uphill village .The area of cultivation is estimated from individual households irrespective of own, revenue land or forest land. The plots of cultivation are very small and sizes are adjusted according to the area available on the Nala side. Sometimes, check dams and irrigation channels are constructed for the flow of water to the plots. In the uphill village , the household with good economical back groundcultivate paddy. In the three villages in foothill, all households go for cultivation in small plots. The per capita cultivation of paddy is highest in Amlet (0.130 ha.) and lowest in Am-ih(0.025 ha.). The production and productivity of paddy (grain and straw) in Agra kunchi , Ahom Buroi, Akelal, Ambuda was 17.5 tons, 33.75 tons, 9.68 tons, and 41.75 respectively **(Table 3,4).** The contribution of different components to totals above-ground productivity showed that the grain contributed 59.64% followed by straw 34.8 % and residue 5.56%

Table 3. Agricultural Crop Productivity of the Singhason Village Ecosystem

Crop		Agra kunchi		Ahom Buroi,		Akelal		Ambuda	
CEREALS		P	T P	P	T P	P	T P	P	T P
1	Paddy *(Oriza sativa)*	-	-	2.424	17.5	-	-	-	-
2	Maize *(Zea mays)*	0.220	0.125	0.340	0.420	0.203	2.200	0.184	1.760
3	Finger*Millet (Eleusinecorocana) MANDIA*	2.061	11.267	2.194	29.681	2.651	50.770	2.744	39.000
4	Pearl*Millet (Pennesetumtyphoides) GHANTIA*	0.381	2.086	0.188	2.550	0.229	4.390	0.322	4.590
5	Common*Millet (Panicumpaludosum) KANGU*	2.737	14.960	1.414	19.125	0.549	10.520	0.864	12.280
6	Barnyard*Millet (Echinochloacolonum) KOSHALA*	3.516	19.713	4.465	60.388	3.683	70.534	3.753	53.339
LEGUMES									
1	RedGram *(Cajanuscajan) KANDULA*	0.826	4.520	0.995	13.464	1.072	20.538	1.236	17.568
2	Jhudanga *(Vignaunguiculata)*	0.269	1.475	0.779	10.540	0.818	15.675	1.350	19.190
3	Katinga *(Vigna sps)*	0.369	2.020	0.331	4.470	0.446	8.551	0.447	6.355
OILSEED									
1	Castor *(Ricinus comunis) JADA*	-	-	0.019	0.259	0.055	1.059	0.032	0.456
2	Niger *(Guizotiaobyssinica)*	-	-	0.015	0.059	0.056	0.034	0.000	-
VEGETABLES									
1	Brinjal *(Solanummelanogena)*	0.411	0.05	0.336	1.2	0.296	0.3	0.329	0.2
2	Tomato *(Lycopersicumesculentum)*	0.165	0.08	0.278	0.45	0.292	0.65	0.288	0.7
3	Simba *(Dolichous lablab)*	-	0.035	-	0.075	-	1.895	-	1.43
CASH CROPS									

1	Turmeric *(Curcuma longa)*	0.564	0.548	0.893	10.33	0.842	6.072	0.826	3.42
2	Ginger *(Zingiberofficinale)*	0.988	0.12	2.562	25.83	2.547	27.74	2.621	17.83
3	Banana*(Musa paradisiaca) t/ plant*	-	-	0.008	2.37	0.009	2.925	0.0098	1.565
FRUITS									
1	Jack *Fruit (Artocarpusintegrefolia) (t/plant)*	0.047	4.525	0.049	9.15	0.052	7.67	0.056	4.28
2	Mango *(Mangiferaindica)*	1.114	1.805	1.119	3.625	1.406	23.8	2.253	17.61
3	Pine *Apple (Ananas sativa)*	4.348	5.282	2.07	6.69	2.823	47.78	2.539	19.84
4	Orange *(Citrus sinensis) (in numbers)*	-	-	82.27	9050	67.3	4375	62.5	3000
5	Papaya*(Carica papaya) t/plant*	0.0137	1.345	0.0173	5.6	0.0163	6.2	0.0162	3.755
Note: P= Productivity (t ha^{-1} year^{-1}) ; TP= Total production (t)									

Table 4. Agricultural Crop Productivity of the Foothill Village Ecosystem

Crop		Amguri		Am-ih		Amlet,		Akelal-2	
CEREALS		P	T P	P	T P	P	T P	P	T P
1	Paddy *(Oriza sativa)*	3.110	33.75	2.796	9.680	3.192	41.750	-	-
2	Maize *(Zea mays)*	0.193	1.550	0.190	0.870	0.184	0.880	0.192	0.650
3	Finger Millet *(Eleusinecorocana)MANDIA*	2.204	19.900	1.888	7.800	1.706	13.400	1.552	11.380
4	Barnyard Millet *(Echinochloacolonum)KOSHALA*	-	-	-	-	-	-	3.709	27.180
LEGUMME									
1	Red Gram *(Cajanuscajan) KANDULA*	0.702	6.340	0.849	3.510	0.432	3.400	1.537	11.270
2	Jhudanga *(Vignaunguiculata)*	0.636	5.750	0.974	4.025	0.547	4.360	-	-
3	Katinga *(Vigna sps)*	-	-	-	-	-	-	-	-
OILSEED									
1	Castor *(Ricinuscomunis) JADA*	-	-	-	-	-	-	-	-
2	Niger *(Guizotiaobyssinica)*	0.071	0.646	0.078	0.325	0.055	0.435	0.356	2.615
3	Rasi *(Sesamumindicum)*	-	-	-	-	-	-	0.181	1.33
VEGETABLES									
1	Brinjal *(Solanummelanogena)*	0.494	0.2	0.395	0.08	0.271	0.165	0.390	2.56
2	Tomato *(Lycopersicumesculentum)*	0.218	0.92	0.241	0.47	0.248	0.695	0.268	2.11
3	Lady Finger *(Hibiscus esculentus)*	0.300	1.035	0.382	0.48	0.260	0.97	0.277	0.225
4	Simba *(Dolichous lablab)*	-	1.054	-	0.54	-	0.675	-	1.58
CASH CROPS									
1	Cotton *(Gossypiumhirsutum)*	-	-	-	-	-	-	0.799	5.76
2	Tobacco *(Nicotianatobacum)*	-	0.04	-	0.01	-	0.06	-	0.02
3	Banana*(Musa paradisiaca)*	0.009	1.135	0.0086	0.65	0.011	1.75	0.0086	0.36
FRUITS									
1	Jack Fruit *(Artocarpusintegrefolia) (t/plant)*	0.062	1.38	0.056	0.45	0.049	1.58	0.054	0.71
2	Papaya*(Carica papaya) t/plant*	0.0175	0.35	0.012	0.3	0.0138	0.9	0.0156	0.5
Note: P= Productivity (t ha^{-1} year^{-1}) ; TP= Total production (t)									

Productivity of crops under home garden

The cultivation of various vegetables is taken up in backyards or the land around dwelling house for domestic use and marketing of surplus. The production of common vegetables like Brinjal, Tomato, Lady Finger and Simba are recorded from individual household and consolidated for the total village (Table 5& 6).

Table 5. Productivity of Crops Under Home Garden for village Amguri and Am-ih

	Amguri				Am-ih			
	Area (in ha)	Production (in ton)	Consumption (in ton)	Sale (in ton)	Area (in ha)	Production (in ton)	Consumption (in ton)	Sale (in ton)
Brinjal	0.121	0.05	0.05	0	3.562	1.20	0.30	0.90
Tomato	0.486	0.08	0.08	0	1.619	0.45	0.25	0.20
Simba	0.040	0.35	0.35	0.00	0.08	0.075	0.075	0.00
Papaya	0.040	1.345	0.345	1.0	0.08	5.6	2.6	3.0

Table 6. Productivity of Crops Under Home Garden for village Amlet, and Akelal-2

	Amlet,				Akelal-2			
	Area (in ha)	Production (in ton)	Consumption (in ton)	Sale (in ton)	Area (in ha)	Production (in ton)	Consumption (in ton)	Sale (in ton)
Brinjal	1.012	0.3	0.1	0.2	0.607	0.2	0.1	0.1
Tomato	2.226	0.65	0.35	0.3	2.429	0.7	0.35	0.35
Simba	0.24	1.895	0.25	1.645	0.22	1.43	0.23	1.2
Papaya	0.24	6.2	3.2	3.0	0.22	3.755	0.755	3.0

RESULTS

The details of geographical area of the eight villages under study are given in Figures 1-8 with the break-up of components under housing and cultivation (Home garden, shifting cultivation and valley cultivation). The villages are widely separated from each other and boundaries are demarcated by the hilly topography and vegetation. For shifting cultivation and collection of minor forest produce, the forests beyond the village boundary are used by villagers.Per capita cultivated area varies from 0.117 ha. (Patlamba) to 0.329 ha. (D.Kumbharabadi). Forest area is utilized for shifting cultivation and home garden. Paddy cultivation is practiced in one upper hill village (Rhodanga) and three-foot hill villages (Majhihalma, Bhaliabhatta and D. Kumbharabadi) (Fig. 1 to 8). Shifting cultivation is prominent in four villages located in upper hill area (i.e. Patlamba, Rhodanga, Khajuriand, Gortali).Human Population dynamics in villages indicate that average family size varies from 3.8 to 5.2 (Table.7). The literacy rate varies widely from 4.8% in Patlamba to 72% in D. Kumbharbadi.Elder persons above age group of above 40years are totally illiterate in uphill villages, however the adults with age group 25-30yrs have someeducation.The topography plays a major role in the land use with easy gradient slopes with soil cover are mostly used for raising crops under the shifting cultivation. It is always a poly culture locally known as “Dongar” cultivation of all cereals, pulses, oil seeds type complex cropping traditional practice with ecological and economic advantages in rain-fed condition. Other land use category is the valley area cultivation known as “Gudia” or “Padar” which is mostly used for Ginger and Turmeric and some fruit plants surrounding the field or house. The land is mostly used for different cash crops like Bananas,

Orange, Mango, Litchi, Jackfruit etc.The third land use category cultivation is the Nala-beds / aquatic areas with perennial stream flow of water mostly used for paddy. The villages situated at low elevation in the periphery of Sighason, practice paddy cultivation using stream water in very small patches. High rainfall in these areas sometimes lead to speedy flow in Nala-beds washing all crops. Thus, three major categories of land are available for agricultural use. The home-stead village areasare very small with compact houses in rows facing each other with common place. The aquatic area is only streams which are mostly perennial and major common property resource (CPR) is forest land and the uncultivated area.

The material flows were more or less similar among the villages of the Niyamgiri hills, however, crop productivity differed considerably due to perhaps quantities of materials flowed, and more input in case of some crops in valley villages than uphill villages. The details of food consumed in these villages indicated that the local production supported only less than 50 % of requirements and rest met through imports. The increased preference to marketable crops and easy accessibility of food grains imported from plains are the results of market forces. But the reliance on local produce (traditional grains) is relatively high in these villages very similar to Himalayan villages (Maikhuri et al. 1997).

Conclusion

The Agro-ecosystem studies in West Karbi-Anglong district indicated that agricultural in the area can be sustainable if pressure on forestland can be reduced. This could be achieved by reviving the support system and each hectare of agriculture land should be supported by 10-15 ha of forests (Singh et *al*, 1984). Carrying capacity of forests at present seems to be capable of supporting the village agriculture. However, all effort is needed to strengthen the protection mechanism in forest blocks surrounding the villages, and involving the people of these villages in other forest-based livelihood option other than agriculture. Similar recommendations for villages located inside the forests has also been given as a result of one study on human ecology of villages (Upadhyay et al.2012). Intensification of food crop production systems in villages may lead to further loss of many ecosystem functions affecting especially sustainable productivity and nutrient cycling which will ultimately result in continued degradation of Carbon sequestration and biodiversity.

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