*Original Research Article*

# Agroecosystem Sustainability in a Forest dependent Tribal Village in Odisha, India

**Abstract**

The present study was carried out in Niyamgiri hills inhabited by primitive Dongaria tribes in Odisha to assess present state of socioeconomic components of village and efficiencyand 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 eight villages where human population varies from 83 to 312 in uphill villages and 76 to 150 in foothill villages. The cultivated area ranges from 3.37% to 18.85% of the total village geographical area with per capita cultivated area 0.117 to 0.329 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 tocultivate paddy in valleys, shifting (Podu) cultivation practiced in uphill areas, mid hill orchardsbelow the Podu areaand home garden adjoining habitation. Cereals, pulses and oil seeds are grown together in Podu areas. Maize is a major cereal as staple food grown in uphill villages. The village productivity of Millets, legumes andpaddy is much lower than other settled agriculturareas of the stste. The home garden areasare 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 (Jackfruit, Pine apple, Banana, Orange, Mango) 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. Odisha Millet Mission (OMM) 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:** Agriculture, Millet, Forest, Livelihood options, Niyamgiri, Odisha, Podu 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 activitiesby recycling resources within the system (Rabindranath etal., 1981; NishankaandMisra, 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 ,odified 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 Odisha requires an interdisciplinary approachwhich 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 changesby 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 Nyamgirihillsinhabited by primitiveDongariya tribes in Odisha to assess socioeconomic components of village and efficiency of

productionsystems 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 Niyamgiri Forests and to to suggest how conservation objectives can be achieved making village agroecosystem practices sync with ecological requirements.

## STUDY AREA AND ENVIRONMENT

Niyamgiri forest is one of the most important ecological habitats in southern Odisha.It lies between$83^0$17' to $83^0$29' E long and $19^0$22' to $19^{0-}$ 42'N lat. Administrative jurisdiction covers three blocks (Muniguda, Bissam-cuttack, K.Singhpur) of Rayagada district and one block (Lanjigarh) of Kalahandi district. Most part of the forest remains un-surveyed due to inaccessibility. Only few Reserve Forest (RF) and Proposed Reserve Forest (PRF) exist in the Niyamgiri Hill Range covering 125.86 sq km. (Table 2)Most of the forest area remained un-surveyed .Varied topography with continuous valleys and ridges, and unbroken mantle of forest supports very rich bio-diversity involving topical and sub-topical species. It is the cradle of major rivers of Rayagada district with Bansadhara in North and Nagabali in South which flows to the Bay of Bengal through Andhra Pradesh, Niyamgiri Hill Forests in elongated in North-South direction (ca 36 km) with average width of about 15 km and encompasses about 496 sq km area.

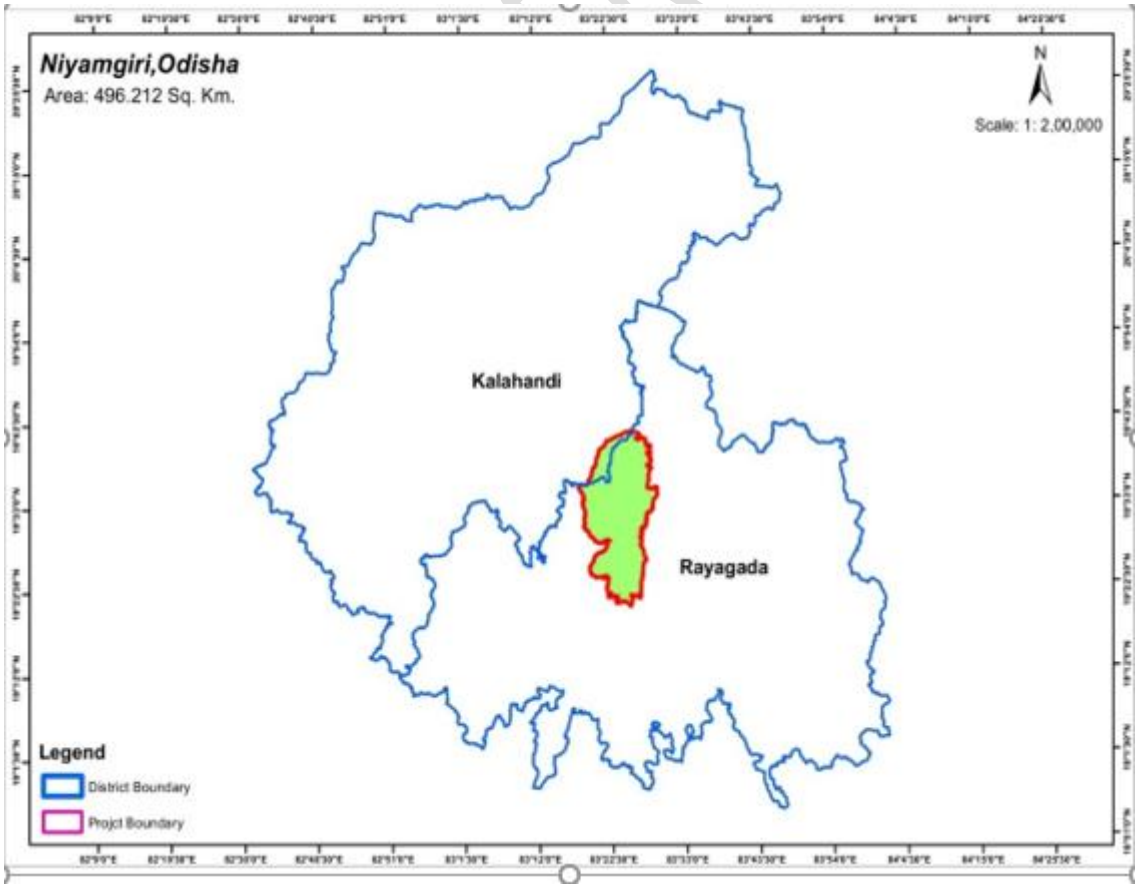



**Plate 1.** Location of Niyamgiri Hills in the District of Rayagada and Kalahandi, Odisha India.

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.Niyamgiri hill range is an extensive area with degraded Sal forest interrupted by practices of shifting (*Podu* ) cultivation near the habitation areas. Inhabitants in the range are *Kandha* tribe namely *'DongriaKandha*'- 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 Niyamgiri Hill Ranges extend in four blocks, the Bissam Cuttack block is selected for the present study because the villages arelocated at approachable distance. Four village settlements at higher elevation inside Niyamgiri Forest are selected for the study of Agro-ecosystems. Another four village settlements selected at the foot hill of Niyamgiri out of which two are closer to market place (urban area) and two are little away from urban area. The toposheet map of the Niyamgiri shows hilly terrain throughout the forest cover and settlements or habitations without road connectivity, far away from each other. The village settlements are-

List 1.Village settlements of hilly terrain

| | |
|---|---|
| Village inside Niyamgiri Hill Forest at higher altitude. | 1. Patlamba 2. Rodanga 3. Khajuri 4. Gortali |
| Villages outside Niyamgiri at the foot hills, away from market place | 5. Majhihalma 6. Bhaliabhatta |
| Villages outside Niyamgiri at the foot hills, nearer to market place | 7. D. Kumbharbadi 8. Papikhunti |

Niyamgiri 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 1013.66 mm to 1491.4 mm over 5 years i.e. 2009 to 2013. 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℃ and 30℃ (data average 2009 to 2013) 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 Niyamgiri 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.

**METHODS 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 Niyamgiri 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 2010 to 2015 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 2010 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 inrespect 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, Mango, 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, sheep, buffalo 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 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 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.

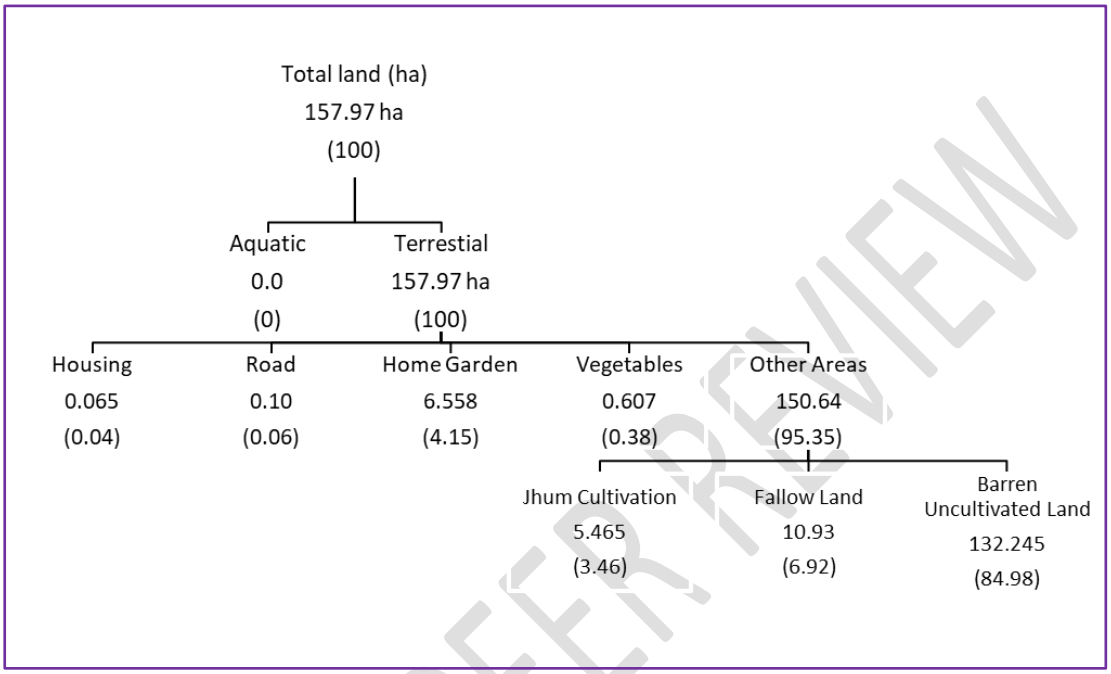



**Figure 1. L**and use pattern of village Patlamba. Data in parenthesis indicates the percentage of contribution.

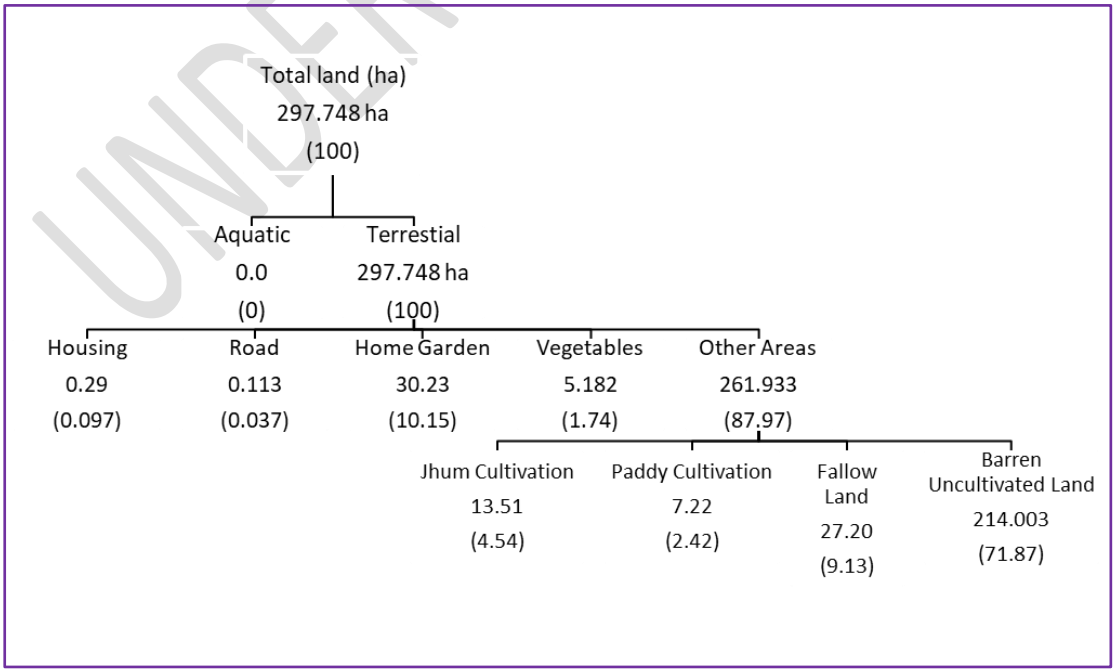



**Figure** land use pattern of village Rodanga. Data in parenthesis indicates the percentage of contribution.

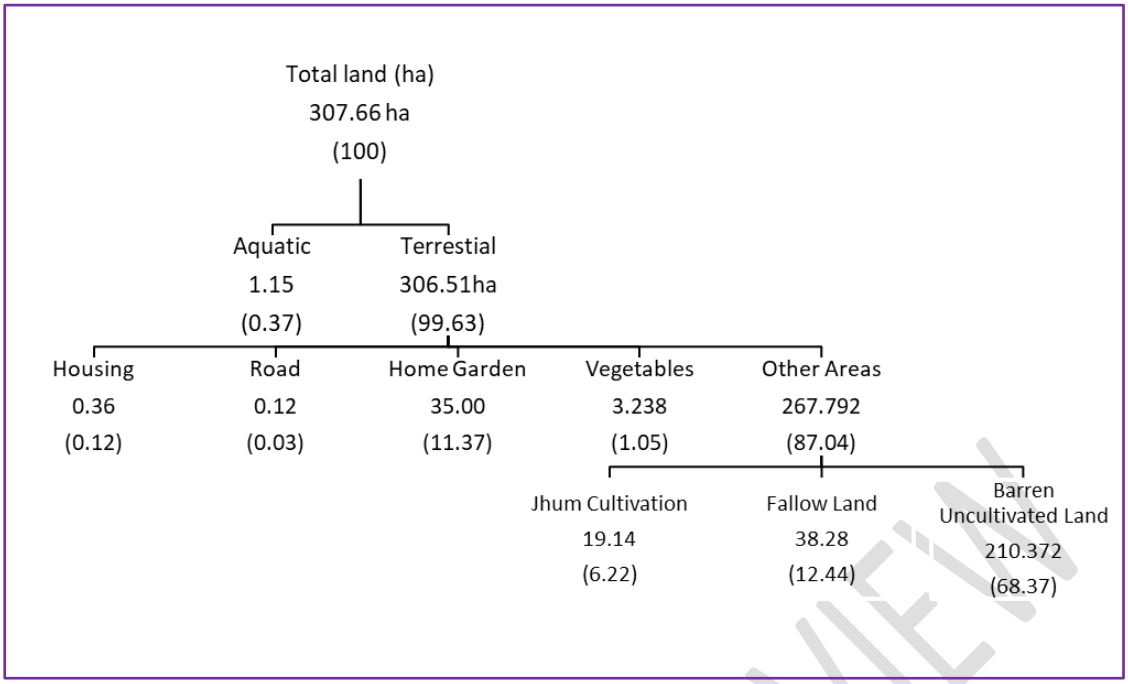



**Figure 1** land use pattern of village Khajuri. Data in parenthesis indicates the percentage of contribution.

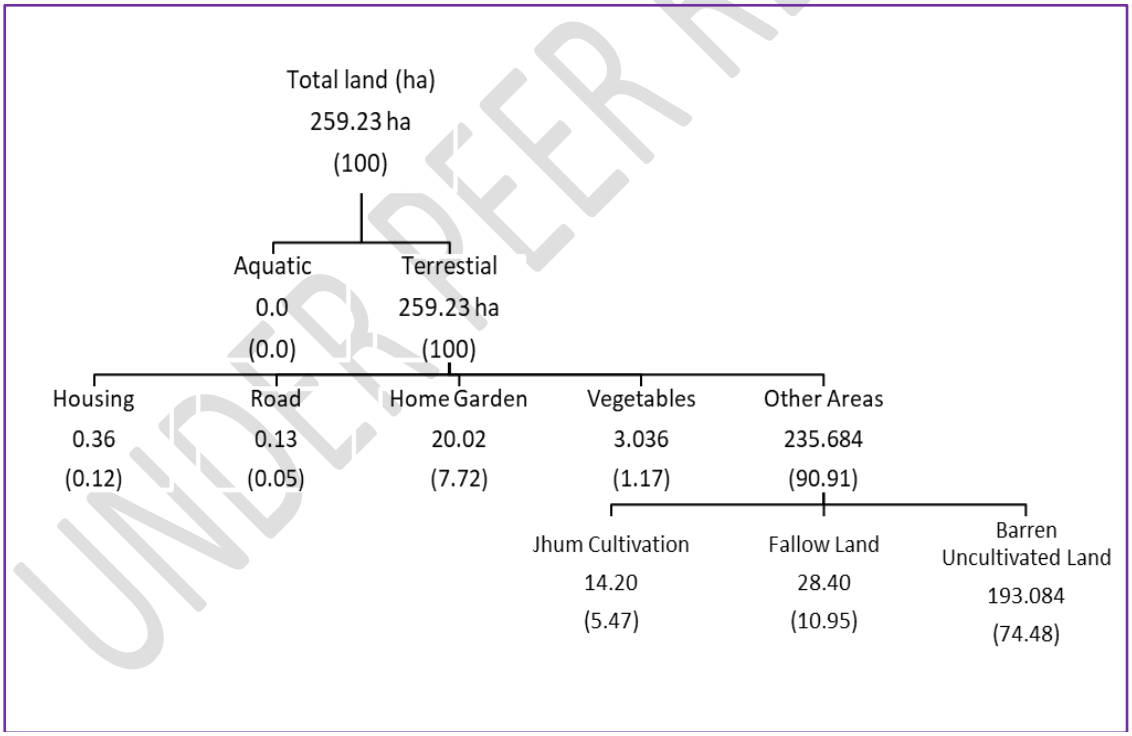



**Figure 2**Graphical representation of land use pattern of village Gartori. Data in parenthesis indicates the percentage of contribution.

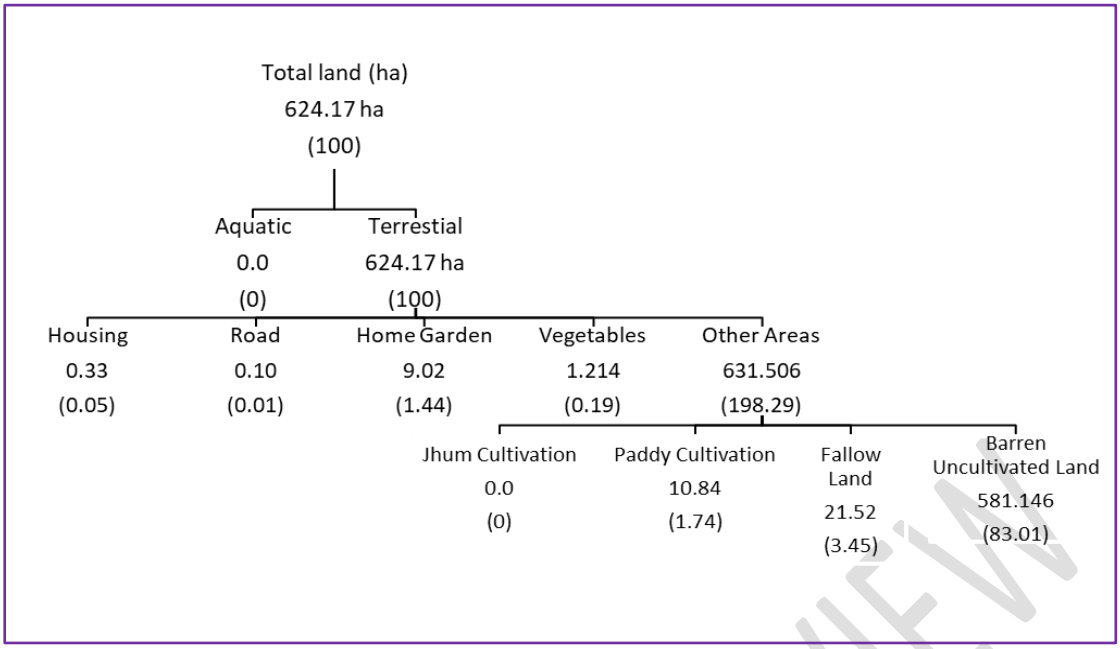



**Figure 3**Graphical representation of land use pattern of village Majhihalma. Data in parenthesis indicates the percentage of contribution.

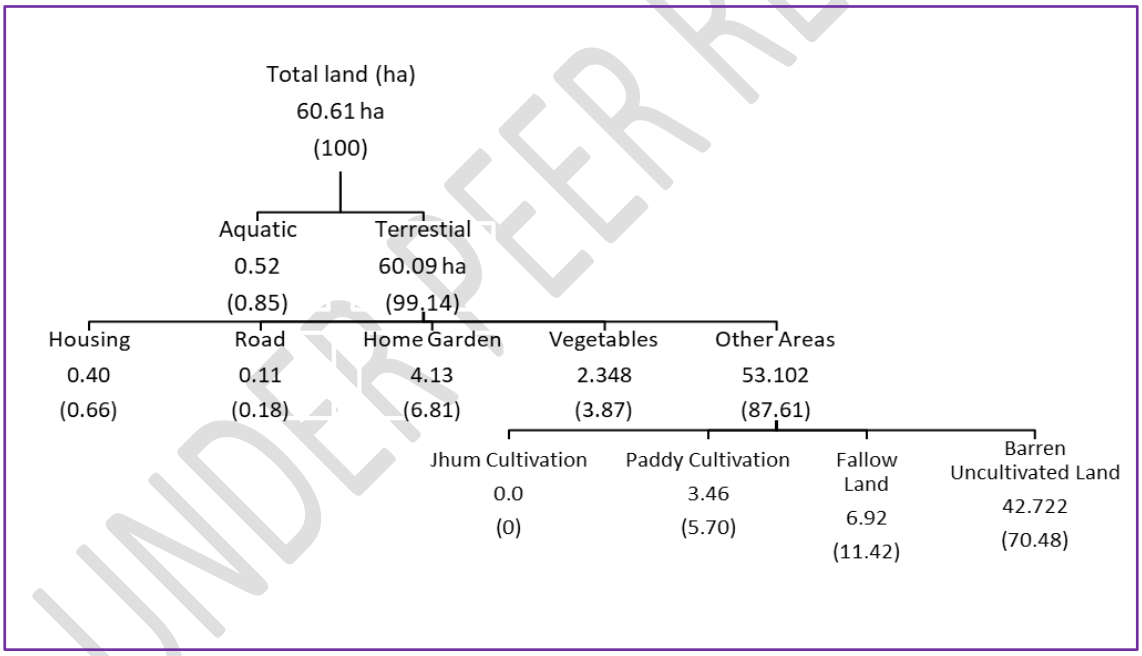



**Figure 4**Graphical representation of land use pattern of village Bhaliabhatta. Data in parenthesis indicates the percentage of contribution.

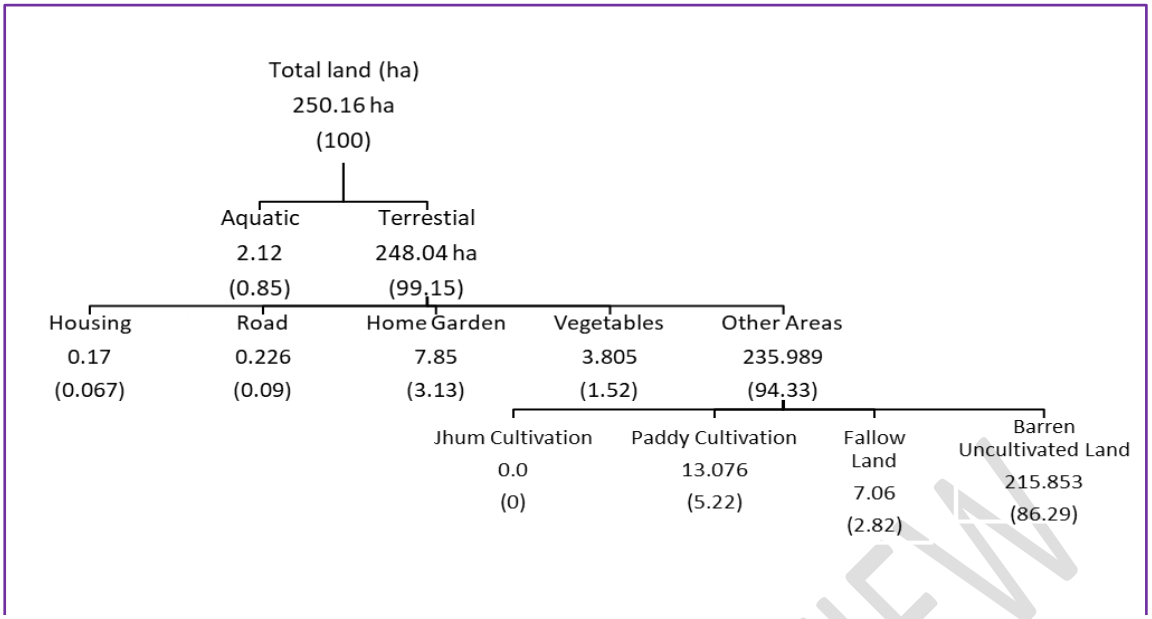



**Figure 5**Graphical representation of land use pattern of village D.Kumbharbadi. Data in parenthesis indicates the percentage of contribution.

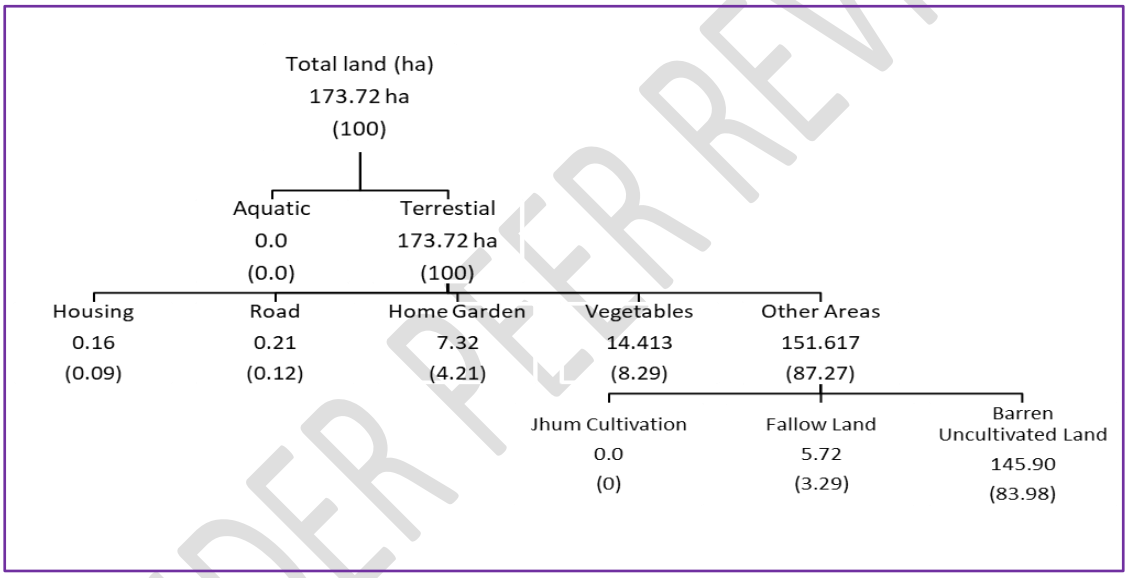



**Figure 6** land use pattern of village Papikhunti. Data in parenthesis indicates the percentage of contribution.



# 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 Niyamgiri Hill study area

| Crop | | Sowing season | Harvest season | Village |
|---|---|---|---|---|
| CEREALS | | | | |
| 1 | Paddy (*Oryza sativa*) | Jun -July | Nov - Dec | R, M, B, D |
| 2 | Maize (*Zea mays*) | May - June | Sept - Oct | P, R, K, G, B, M, D, H |
| 3 | Finger Millet (*Eleusinecorocana*)MANDIA | Jun -July | Sept - Oct | P, R, K, G, B, M, D, H |
| 4 | Pearl Millet (*Pennesetumtyphoides*)GHANTIA | Jun -July | Nov - Dec | P, R, K, G, B, M, D, H |
| 5 | Common Millet (*Panicumpaludosum*)KANGU | May - June | Nov - Dec | P, R, K, G, B, M, D, H |
| 6 | Barnyard Millet (*Echinochloaconlonum*)KOSHALA | Jun -July | Nov - Dec | P, R, K, G, B, M, D, H |
| LEGUME | | | | |
| 1 | Red Gram (*Cajanuscajan*) KANDULA | Jun -July | Jan - Feb | P, R, K, G, B, M, D, H |
| 2 | Jhudanga ( *Vignaunguiculata*) | Jun -July | Oct - Nov | P, R, K, G, B, M, D |
| 3 | Katinga (*Vigna*sps) | Jun -July | Sept - Oct | PRKG |
| OILSEED | | | | |
| 1 | Castor (*Ricinuscomunis*) JADA | Jun -July | Feb - March | R, K, G |
| 2 | Niger ( *Guizotiaobyssinica* ) | Jun -July | Feb - March | R, K, B, M, D, H |
| 3 | Rasi ( *Sesamumindicum*) | Sept - Oct | Feb - March | H |
| | | | | |
| | VEGETABLES | | | |
| 1 | Brinjal (*Solanum melanogena*) | Aug -Sept | Nov - Dec | P, R, K, G, B, M, D, H |
| 2 | Tomato (*Lycopersium esculentum*) | Aug -Sept | Nov - Dec | P, R, K, G, B, M, D, H |
| 3 | Lady Finger (*Hibiscus esculentus*) | Aug -Sept | Nov - Dec | B, M, D, H |
| 4 | Simba (*Dolichus*sp) | Aug -Sept | Nov - Dec | P, R, K, G, B, M, D, H |
| | CASH CROPS | | | |
| 1 | Cotton (*Gossypium hirsutum*) | June - July | Nov - Dec | H |
| 2 | Tobacco (*Nicotiana tabacum*) | June - July | Nov - Dec | M, B, D, H |
| 3 | Turmeric (*Curcuma longa*) | April -May | Jan - Feb | P, R, K, G |
| 4 | Ginger (*Zingiber officinale*) | April -May | Nov - Dec | P, R, K, G |
| | FRUITS | | | |
| 1 | Jack Fruit (*Artocarpus integrefolia*) | | Green (Feb - March ) June-July | P, R, K, G, M, B, D, H |
| 2 | Mango ( *Mangifera indica*) | | May-June | P, R, K, G |
| 3 | Pine Apple (*Ananas sativa*) | | June-July | P, R, K, G |
| 4 | Orange (*Citrus sinensis*) | | Sept-Oct | R, K, G |
| *Note: P- Patlamba, R- Rodang ,K- Khajuri,G- Gortali,M- Majhihalma, B- Bhaliabhatta, D- D. Kumbharbhadi, H- Papikhunti* | | | | |



## 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 locationviz.,*Podu* 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 Productivity of The **each of** Village Ecosystemfor the year 2010-11 **is given in Table 3.**

.

**Table 2.**Area Under Cultivation of Different Crops (ha) in the Village Under Study During

| | P | R | K | G | M | B | D | H |
|---|---|---|---|---|---|---|---|---|
| Podu 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 | - | - | - | - |
| Caster 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: P- Patlamba, R- Rodang ,K- Khajuri,G- Gortali, M- Majhihalma, B- Bhaliabhatta, D- D. Kumbharbhadi, H- Papikhunti* | | | | | | | | |

## Podu Cultivation

Shifting cultivation commonly known as Podu cultivation is a prevalent practice in hilly forest areas, mostly an adopted agriculture system by the tribal community. The areas of individual household's Podu cultivationwere ascertained by sample field verification of each village. The village-wise area under different crops is given in Table-2. Podu cultivation is prominent in uphill villages of Niyamgiri, whereas it is rarely practised in foothill villages. Here also, the Dongaria Tribe practice Podu 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 caster 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 10.

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

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

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

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


**Picture** 5.Grains of Common Millet (KANGU)

**Picture** 6. Grains of Finger Millet (MANDIA)


Picture **7.**De-husked Grains of Barnyard Millet (KOSHALA)

Picture **8.**Grains of Pearl Millet (GHANTIA)


**Picture** 9.Seeds of *Vigna* species

**Picture 10**.Seeds of *Cajanus cajan*

## Mid-Hill Cultivation (Orchards)

The forest area below the Podu cultivation area and above the village habitation is cultivated and used for developing different orchards like; Mango, Orange, Jackfruits, etc., with under crops like; Pineapple, Zinger and Turmeric. All these crops are mostly induced practice with the support of DongariaKandha Development Agency (DKDA) 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 $2^{nd}$ or $3^{rd}$ year and planted again during summer. The area of different household is calculated for different villages given in Table 2. 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 11.Pineapple Cultivation at Mid-hill Orchards

Picture 12. Jackfruit in Niyamgiri Forest

**Picture** 13.Mid hill Orchard at Village Khajuri

**Picture** 14.Vegetable Cultivation at Papikhunti

Picture 15. Turmeric in mid hill Orchard at Village Patlamba

Picture 16. Paddy cultivation at Rodanga

## 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 Chatikona. Home garden provides variety of requirements to the tribal community round the year. Among vegetables,Tomato, Brinjal, Bin, Sweet Potato, Chilly are commonly practiced. The cultivation of Tobacco is taken up in small

scales by the foothill villagers for chewing snuff and black cigar (pika, rolled Tabaco leaf). Apart from these, Papayas, Pumpkin, Bitter-Gourd are alsocultivated. 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 villagevaries from 0.61ha(Patlamba) to 15.2 ha(Papikhunti) across different villages.

## Valley Cultivation

Valley cultivation is taken up near the available natural water source i.e. Streams andNalas flowing below the habitations. It is mostly the paddy crop practiced in one uphill village Rodanga and three foothill villages viz., Majhihalma, BhaliabhattaandD.Kumbharbadi. 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 of Rodanga, 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 D.Kumbharbadi (0.130 ha.) and lowest in Rodanga (0.025 ha.). The total area of cultivation of paddy in the villages is much lower in Bhaliabata-3.46 ha comparedto Rodanga with 7.22 ha., Majhihalma10.84 ha.,and D.Kumbharbadi13.07 ha. (Table2).Paddy **(***Oryza sativa* L**.)** cultivation is taken up nala beds and its adjoining areas for which primary productivity is calculated from the dry weight of the above ground components. The production of paddy (grain and straw) in Rodanga, Majhihalma, BhaliabataandD. Kumbharbadi was 17.5 tons, 33.75 tons, 9.68 tons, and 41.75 respectively (Table 3,4). Annual productivity was highest in D.Kumbharbadi. 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% (Table5-8).

**Table 3.**Agricultural Crop Productivity of The Uphill Village Ecosystem

| Crop | | Patlamba | | Rodanga | | Khajuri | | Gortali | |
|---|---|---|---|---|---|---|---|---|---|
| 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)* | | | | | | | | | |

## Cereals

Finger Millet(*Eleusine corocana*Gertn.) commonly known as Mandia is a staple food for the local community and produced in large quantities to meet the annual requirement. It is cultivated in Podu cultivation as a component along with other cereals like pearl Millet , common Millet , barnyard Millet s, legume and oil seeds. The total production i.e. grain and straw of different crops were considered separately as it is a mixed cropping pattern. The productivity of finger Millet varies from 2.061 $tha^{-1}yr^{-1}$to 2.744 t $ha^{-1}yr^{-1}$in uphill villages (Table 3-4)and from 1.552 $t.ha^{-1}yr^{-1}$to 2.204 $tha^{-1}yr^{-1}$in foothill villages (Table 3-4). As regards the total production, the highest production is observed in village Khajuri. Disaggregation of the crop products are shown in Tables 5-8.

**Table 4.** Agricultural Crop Productivity of The Foothill Village Ecosystem

| Crop | | Majhihalma | | Bhaliabhatta | | D. Kumbharbadi | | Papikhunti | |
|---|---|---|---|---|---|---|---|---|---|
| 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)KOSHA LA* | - | - | - | - | - | - | 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)* | | | | | | | | | |

Common Millet **(***Panicumpaludosum*) is locally known as "Kangu" in Dongaria villages. Kangu is cultivated as mixed crop in the shifting cultivation area along with other cereal, pulses and oil seeds. The actual area it occupies in a mixed cropping pattern was taken by field measurement of individual area. The productivity was 2.737t ha-1yr-1 in Patlamba, 1.411t inRodanga, 0.549t ha-1yr-1 in Khajuri and 0.864t ha-1yr-1 in Gortali villages (Table3).The Kangu is not practiced in foothill villages of Niyamgiri (Table 3-4).Pearl Millet(*Pennesetumtyphoides*)is also cultivated in shifting cultivation area along with other cereals, pulses and oilseeds and locally known as "Ghantia". It is also practiced in uphill villages of Niyamgiri with maximum productivity in Patlamba village 0.381t ha-1yr-1 and minimum of 0.188t ha-1yr-1 in Rodanga . Highest production was recorded in Gortali 4.590t which as normally consumed with rare disposal outside.BarnyardMillet(*Echinochloacolonum*) is locally known as Koshala and cultivated as mixed crop in shifting cultivation area along with other Millet s, pulses and oilseeds in Rodanga (4.465t ha-1yr-1 ) with minimum productivity in Patlamba (3.516t ha-1yr-1 ). It is a major cereal of the uphill villages. Total production is

highest in Khajuri village (70.534t) with lowest production in Patlamba (19.713t). This meets major food requirement of the society.

**Legumes and oil seeds**

Red Gram(*Cajanuscajan*)is one of the most common pulses cultivated in all villages. The highest productivity recorded in the village Papikhunti (1.537tha-1yr-1 ) whereas the lowest productivity was recorded in the village D. Kumbharabadi 0.432tha-1yr-1 . Khajuri village recorded the highest production quantity of 20.538t followed by Gortali (17.568t), Rodanga (13.464t) Papikhunti (11.270t) Majhihalma (6.340t) Patlamba(4.520t) Bhaliabhatta(3.510t) and D. Kumbharabadi(3.4t). In green condition (immature fruits) it is used as vegetables but mature production is good saleable pulses.Jhudanga (*Vignaunguilulata*) legume is used as vegetable in green stage and as pulses in mature harvest. Seven villages produce Jhudanga except Papikhunti. Highest production recorded for Gortali(19.190t) whereas Patlamba produced the minimum quantity of 1.475t. Gortali showed the highest productivity of 1.350tha$^{-1}$yr$^{-1}$.Kating pulses are produced by the four uphill villages. It is commonly cultivated as mixed crop and used as pulses. Maximum production of 8.551t was recorded in Khajuri village though highest productivity was recorded in Gortali (0.447tha-1yr-1 ). The production is entirely consumed by villagers. Among OilSeeds**,** Castor (*Ricinuscommunis*) is sown in rows on sides of shifting cultivation area and seeds collected when mature. It is practiced in uphill villages only. The productivity is only indicative of individual production subjected to density of crop. Niger (*Guizotiaobyssinica*) is cultivated in small plots and used as oil seeds. The productivity was highest in Papikhunti 0.356tha-1yr-1 with highest production of 2.615t. Rasi(*Sesamum indicum*) is cultivated only in one foothill village Papikhunti.

**Vegetables (Home Garden), Cash Crops and Fruits**

Common vegetables cultivated are Brinjal, Tomato, Lady Finger and Simba. The product is only meant for domestic use in uphill villages whereas commercial cultivation is recorded from foothill villages. Papikhunti is the highest producer of vegetables which is marketed in weekly market of Chatikona home garden. Turmeric (Curcuma Longa) and ginger (*Zingiberofficinale*) are major cash crops of the uphill villages cultivated in mid hill areas. The maximum production has been recorded from Rodanga for turmeric (10.33t) with highest productivity 0.893tha$^{-1}$yr$^{-1}$(Table 3-4)Patlamba has minimum production 0.548t and lowest productivity 0.564 t ha$^{-1}$yr$^{-1}$for turmeric. Cotton (*Gossypiumhirsutum*) and Tobacco (*Nicotiana tabacum*) are not cultivated in uphill villages but noticed in few foothill villages. It is in small quantity for self-use not sold outside.Jack Fruit(*Artocarpusintegrifolia*) (green) is collected and sold as vegetables in late winter. Truckloads of jack fruits exported to distant places of Odisha and Chhattisgarh. It is centre for green jack fruit in Odisha and market value is better than matured ripen ones. Green

jack fruit is produced in all villages both uphill and downhill villages. Maximum production is recorded in Rodanga (9.15t). Almost all crop is sold in green condition which has great demand.Mango cultivated variety has been raised in different villages with assistance of DKDA. The laborious family has developed good orchards in mid hill areas and growing pineapple as under crop. The productivity varies from 1.114 (Patlamba) to 2.253t ha-1yr-1 (Gortali) and it is mostly sold out.Pineapple(*Ananas sativa*) is generally grown as under crop in Mango orchards and sometimes pure crop raised in slope of mid hill. Highest quantity was produced in Khajurivillage (47.78t) and lowest production recorded from Patlamba (5.282t). This is marketed in weekly markets, Railway Platforms and delivered to traders at village site. It is not produced in foothill villages.Orange(*Citrus sinensis*)cultivated varieties promoted by DKDA has been successful in some villages of uphill areas. It has also good local market for quality of fruit. Railway communication helps in marketing of different products. Highest production was recorded for village Rodanga (9050 numbers).Papaya(*Carica papaya*) Plants are grown in home garden area and highest production was recorded from village Rodanga (5.6t) which is sold outside.

## Disaggregation of agriculture productivity

The biomass production of different crops was taken into account for individual households in each village. The grains were separated from straw and residues for cereals, pulses and oilseeds. The grains of different crops added together to be utilized by human being whereas the straw and residue are either left to nature to decay or partly utilized by domestic animals. The biomass value of each crop of each village is tabulated in Tables 5-8 for the calculation of energy value.

**Table 5.**Disaggregation of Agriculture Productivity (kg $ha^{-1}$ ) in village PatlambaandRodanga

| Crop | PATLAMBA | | | | RODANGA | | | |
|---|---|---|---|---|---|---|---|---|
| | Productivity | Grains | Straw | Residue | Productivity | Grains | Straw | Residue |
| Paddy | - | - | - | - | 2424 | 1445.81 | 843.96 | 133.94 |
| Finger Millet (Mandia) | 2061.83 | 701 | 989.64 | 371.19 | 2194.02 | 0.757 | 1075.20 | 361.82 |
| Pearl Millet (Ghantia) | 381 | 110.50 | 224.65 | 45.85 | 188 | 56.4 | 112.8 | 18.80 |
| Common Millet (Kangu) | 2737 | 424.45 | 1779.05 | 533.5 | 1414 | 226.24 | 904.96 | 282.8 |
| Barnyard Millet (Koshala) | 3516.43 | 633 | 2354.75 | 528.68 | 4465 | 803.71 | 2962.27 | 625.07 |
| Maize (seed) | 220 | 220.0 | - | - | 340 | 340.0 | - | - |
| Legume | | | | | | | | |
| Redgram (Kandula) | 826 | 181.82 | 570.15 | 74.02 | 995.03 | 229 | 677.06 | 88.97 |
| Jhudanga | 269 | 51.06 | 112.70 | 105.23 | 779 | 144.12 | 334.95 | 299.92 |
| Kating | 369 | 106.86 | 228.34 | 33.79 | 331 | 99.22 | 201.71 | 30.07 |
| Oil seed | | | | | | | | |
| Castor Seed | - | - | - | - | 19 | 19.00 | - | - |
| Niger | - | - | - | - | 15 | 3.17 | - | 11.83 |

**Table 6.** Disaggregation of Agriculture Productivity (kg $ha^{-1}$) in villages

| Crop | KHAJURI | | | | GORATALI | | | |
|---|---|---|---|---|---|---|---|---|
| | Productivity | Grains | Straw | Residue | Productivity | Grains | Straw | Residue |
| Paddy | - | - | - | - | - | - | - | - |
| Finger Millet (Mandia) | 2651 | 927.87 | 1272.50 | 450.62 | 2744 | 961.10 | 1290.59 | 492.30 |
| Pearl Millet (Ghantia) | 229 | 66.50 | 130.72 | 31.77 | 322 | 90.14 | 183.44 | 48.41 |
| Common Millet (Kangu) | 549 | 87.82 | 356.79 | 104.39 | 864 | 138.25 | 561.60 | 164.15 |
| Barnyard Millet (Koshala) | 3683.48 | 663.00 | 2431.00 | 589.48 | 3753.57 | 676.00 | 2551.93 | 525.64 |
| Maize (seed) | 203 | 203.0 | - | - | 185 | 185.0 | - | - |
| Legume | | | | | | | | |
| Redgram (Kandula) | 1072.49 | 236.00 | 718.58 | 117.91 | 1236.3 | 272.00 | 853.08 | 111.228 |
| Jhudanga | 818 | 151.33 | 343.53 | 323.13 | 1350 | 243.05 | 567.08 | 539.85 |
| Kating | 446.31 | 125.00 | 267.85 | 53.46 | 477.35 | 148.00 | 286.44 | 42.91 |
| Oil seed | | | | | | | | |
| Castor Seed | 0.055 | 0.055 | - | - | | 0.032 | - | - |
| Niger | 56 | 11.832 | - | 44.167 | - | - | - | - |

**Table 7.**Disaggregation of Agriculture Productivity (Kg $ha^{-1}$ ) in villages

| Crop | MAJHIHALMA | | | | BHALIABHATTA | | | |
|---|---|---|---|---|---|---|---|---|
| | Productivity | Grains | Straw | Residue | Productivity | Grains | Straw | Residue |
| Paddy | 3110 | 1855.509 | 1082.85 | 171.97 | 2796 | 1667.84 | 973.51 | 154.64 |
| Finger Millet (Mandia) | 2204 | 794.10 | 1102.88 | 307.01 | 1888 | 660.8 | 925.12 | 302.08 |
| Maize (seed) | 193 | 193.0 | - | - | 190 | 190.0 | - | - |
| **Legume** | | | | | | | | |
| Redgram (Kandula) | 702 | 168.63 | 491.84 | 51.52 | 849 | 182.61 | 568.90 | 97.48 |
| Jhudanga | 636 | 248.86 | 279.84 | 107.30 | 974 | 175.44 | 428.80 | 369.75 |
| **Oil seed** | | | | | | | | |
| Niger | 71 | 15.01 | 55.99 | 0 | 78 | 16.48 | 61.52 | - |

Table 8.Disaggregation of Agriculture Productivity (Kg $ha^{-1}$ ) in villages

| Crop | D. KUMBHARBADI(kg $ha^{-1}$) | | | | PAPIKHUNTI(kg $ha^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | Productivity | Grains | Straw | Residue | Productivity | Grains | Straw | Residue |
| Paddy | 3192 | 1903.73 | 1110.89 | 176.61 | - | - | - | - |
| Finger Millet (Mandia) | 1706 | 562.72 | 835.55 | 307.72 | 1552 | 559.15 | 729.9 | 262.94 |
| Barnyard Millet (Koshala) | - | - | - | - | 3709 | 723.24 | 2447.83 | 537.92 |
| Maize (seed) | 184 | 184.0 | - | - | 192 | 192.0 | - | - |
| **Legume** | | | | | | | | |
| Redgram (Kandula) | 432 | 90.84 | 302.78 | 38.37 | 1537 | 368.90 | 1014.39 | 153.70 |
| Jhudanga | 547 | 98.48 | 240.62 | 207.9 | - | - | - | - |
| **Oil seed** | | | | | | | | |
| Castor Seed | - | - | - | - | - | - | - | - |
| Niger | 55 | 11.62 | 43.37 | 0 | 356 | 75.23 | 280.76 | - |
| Rasi | - | - | - | - | 181 | 75.73 | 105.26 | - |

## Disaggregation of plant biomass component

The total production of biomass is divided into grain, straw and residue basing on the sampling result of each village. This provides data on total grain production of the village which will be consumed or sold outside. Similarly, the straw and residue which are properly utilized by the foothill villagers as domestic animal feed is left unused by the uphill villagers mostly allowing natural decay. The village wise production of grain straw and residue is detailed in Table 9 to 16.The disaggregation of different components such as grain straw and residue are shown as percentage contribution of the component to the productivity.

**Table 9.**Disaggregation of Plant Biomass Components of village Patlamba

| CROPS | PATLAMBA | | | |
|---|---|---|---|---|
| | Total Production Mg year $^{-1}$ | Disaggregation (Mg) | | |
| | | Grains | Straw | Residue |
| Cereals | | | | |
| Paddy | - | - | - | - |
| Maize | 0.125 | 0.125 | - | - |
| Finger Millet | 11.267 | 3.830 | 5.407 | 2.028 |
| Pearl Millet | 2.086 | 0.605 | 1.230 | 0.251 |
| Common Millet | 14.960 | 2.320 | 9.724 | 2.916 |
| Barnyard Millet | 19.713 | 3.550 | 13.207 | 2.955 |
| Legume | | | | |
| Kandula | 4.520 | 0.995 | 3.120 | 0.405 |
| Jhudanga | 1.475 | 0.280 | 0.618 | 0.577 |
| Kating | 2.020 | 0.585 | 1.250 | 0.185 |
| Oil seed | | | | |
| Castor | - | - | - | - |
| *N.B. Total production of the crops was obtained by multiplying the productivity with the area under cultivation of the respective crop.* | | | | |

**Table 10.**Disaggregation of Plant Biomass Components of village Rodanga

| CROPS | RODANGA | | | |
|---|---|---|---|---|
| | Total Production (Mg year $^{-1}$) | Disaggregation (Mg) | | |
| | | Grains | Straw | Residue |
| Cereals | | | | |
| Paddy | 17.5 | 10.438(Rice 7.002) | 6.093 | 0.967 |
| Maize | 0.420 | 0.420 | - | - |
| Finger Millet | 29.681 | 10.240 | 14.545 | 4.894 |
| Pearl Millet | 2.550 | 0.765 | 1.530 | 0.255 |
| Common Millet | 19.125 | 3.060 | 12.240 | 3.825 |
| Barnyard Millet | 60.388 | 10.870 | 40.064 | 8.454 |
| Legume | | | | |
| Kandula | 13.464 | 3.098 | 9.161 | 1.203 |
| Jhudanga | 10.540 | 1.950 | 4.532 | 4.058 |
| Kating | 4.470 | 1.340 | 2.724 | 0.406 |
| Oil seed | | | | |
| Castor | 0.259 | 0.259 | - | 0 |
| Niger | 0.059 | 0.012 | - | 0.047 |
| N.B. Total production of the crops was obtained by multiplying the productivity with the area under cultivation of the respective crop. | | | | |

**Table 11.**Disaggregation of Plant Biomass Components of village Khajuri

| CROPS | KHAJURI | | | |
|---|---|---|---|---|
| | Total Production Mg year $^{-1}$ | Disaggregation (Mg) | | |
| | | Grains | Straw | Residue |
| **Cereals** | | | | |
| Paddy | - | - | - | - |
| Maize | 2.2 | 2.2 | - | - |
| Finger Millet | 50.770 | 17.77 | 24.370 | 8.630 |
| Pearl Millet | 4.390 | 1.275 | 2.506 | 0.609 |
| Common Millet | 10.520 | 1.683 | 6.837 | 2.000 |
| Barnyard Millet | 70.534 | 12.695 | 46.550 | 11.287 |
| **Legume** | | | | |
| Kandula | 20.538 | 4.518 | 13.761 | 2.257 |
| Jhudanga | 15.675 | 2.900 | 6.583 | 6.192 |
| Kating | 8.551 | 2.394 | 5.131 | 1.024 |
| **Oil seed** | | | | |
| Castor | 1.059 | 1.059 | - | 0 |
| Niger | 0.034 | 0.007 | - | 0.027 |
| *N.B. Total production of the crops was obtained by multiplying the productivity with the area under cultivation of the respective crop.* | | | | |

**Table 12.**Disaggregation of Plant Biomass Components of village Gortali

| CROPS | GORTALI | | | |
|---|---|---|---|---|
| | Total Production (Mg year $^{-1}$) | Disaggregation (Mg) | | |
| | | Grains | Straw | Residue |
| **Cereals** | | | | |
| Paddy | - | - | - | - |
| Maize | 1.760 | 1.760 | - | - |
| Finger Millet | 39.000 | 13.660 | 18.343 | 6.997 |
| Pearl Millet | 4.590 | 1.285 | 2.615 | 0.690 |
| Common Millet | 12.280 | 1.965 | 7.982 | 2.333 |
| Barnyard Millet | 53.339 | 9.601 | 38.268 | 7.465 |
| Legume | | | | |
| Kandula | 17.568 | 3.865 | 12.122 | 1.580 |
| Jhudanga | 19.190 | 3.455 | 8.061 | 7.674 |
| Kating | 6.355 | 1.970 | 3.813 | 0.571 |
| Oil seed | | | | |
| Castor | 0.456 | 0.456 | - | - |
| *N.B. Total production of the crops was obtained by multiplying the productivity with the area under cultivation of the respective crop.* | | | | |

**Table 13.**Disaggregation of Plant Biomass Components of village Majhihalma

| CROPS | MAJHIHALMA | | | |
|---|---|---|---|---|
| | Total Production (Mg year $^{-1}$) | Disaggregation (Mg) | | |
| | | Grains | Straw | Residue |
| **Cereals** | | | | |
| Paddy | 33.75 | 20.13 (Rice -13.48) | 11.75 | 1.86 |
| Maize | 1.55 | 1.55 | - | - |
| Finger Millet | 19.90 | 7.170 | 9.958 | 2.772 |
| **Legume** | | | | |
| Kandula | 6.340 | 1.523 | 4.442 | 0.375 |
| Jhudanga | 5.750 | 1.150 | 2.530 | 2.070 |
| Oil seed | | | | |
| Niger | 0.646 | 0.136 | 0 | 0.509 |
| *N.B. Total production of the crops was obtained by multiplying the productivity with the area under cultivation of the respective crop.* | | | | |

**Table 14.**Disaggregation of Plant Biomass Components of village Bhaliabhatta

| CROPS | BHALIABHATTA | | | |
|---|---|---|---|---|
| | Total Production Mg year $^{-1}$ | Disaggregation (Mg) | | |
| | | Grains | Straw | Residue |
| **Cereals** | | | | |
| Paddy | 9.68 | 5.78(Rice – 3.87) | 3.37 | 0.534 |
| Maize | 0.87 | 0.87 | - | - |
| Finger Millet | 7.80 | 2.73 | 3.822 | 1.248 |
| **Legume** | | | | |
| Kandula | 3.510 | 0.755 | 2.352 | 0.403 |
| Jhudanga | 4.025 | 0.725 | 1.772 | 1.528 |
| Oil seed | | | | |
| Niger | 0.325 | 0.069 | 0 | 0.256 |
| N.B. Total production of the crops was obtained by multiplying the productivity with the area under cultivation of the respective crop. | | | | |

**Table 15.**Disaggregation Of Plant Biomass Components of village D. Kumbharbadi

| CROPS | D KUMBHARBHADI | | | |
|---|---|---|---|---|
| | Total Production (Mg year $^{-1}$) | Disaggregation (Mg) | | |
| | | Grains | Straw | Residue |
| Cereals | | | | |
| Paddy | 41.75 | 24.90(Rice 16.705) | 14.53 | 2.31 |
| Maize | 0.88 | 0.88 | - | - |
| Finger Millet | 13.40 | 4.420 | 6.563 | 2.417 |
| Legume | | | | |
| Kandula | 3.40 | 0.715 | 2.383 | 0.302 |
| Jhudanga | 4.36 | 0.785 | 1.918 | 1.113 |
| Oil seed | | | | |
| Niger | 0.435 | 0.092 | 0 | 0.343 |
| *N.B. Total production of the crops was obtained by multiplying the productivity with the area under cultivation of the respective crop.* | | | | |

**Table 16.** Disaggregation of Plant Biomass Components of village Papikhunti

| CROPS | PAPIKHUNTI | | | |
|---|---|---|---|---|
| | Total Production Mg year $^{-1}$ | Disaggregation (Mg) | | |
| | | Grains | Straw | Residue |
| **Cereals** | | | | |
| Maize | 0.65 | 0.65 | - | - |
| Finger Millet | 11.38 | 4.10 | 5.352 | 1.928 |
| Barnyard Millet | 27.180 | 5.30 | 17.938 | 3.942 |
| Legume | | | | |
| Kandula | 11.27 | 2.705 | 7.438 | 1.127 |
| **Oil seed** | | | | |
| Niger | 2.615 | 0.552 | - | 2.062 |
| Rasi | 1.33 | 0.556 | - | 0.774 |
| *N.B. Total production of the crops was obtained by multiplying the productivity with the area under cultivation of the respective crop.* | | | | |

**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 17-20).

Table 17Productivity of Crops Under Home Garden for village Patlamba and Rodango

| | PATLAMBA | | | | RODANGA | | | |
|---|---|---|---|---|---|---|---|---|
| | 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 18 Productivity of Crops Under Home Garden for village Khajuri and Gortali

| | KHAJURI | | | | GORATALI | | | |
|---|---|---|---|---|---|---|---|---|
| | 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 |

Table 19 Productivity of Crops Under Home Garden for village Majhihalma and Bhaliabhatta

| | MAJHIHALMA | | | | BHALIABHATTA | | | |
|---|---|---|---|---|---|---|---|---|
| | 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 | 0.404 | 0.2 | 0.1 | 0.1 | 0.202 | 0.08 | 0.08 | 0 |
| Tomato | 0.566 | 0.92 | 0.32 | 0.6 | 1.943 | 0.47 | 0.17 | 0.3 |
| Lady's Finger | 0.607 | 1.035 | 0.2 | 0.835 | 0.202 | 0.48 | 0.18 | 0.3 |
| Simba | 0.18 | 1.054 | 0.25 | 0.804 | 0.05 | 0.54 | 0.23 | 0.3 |
| Papaya | 0.18 | 0.35 | 0.35 | 0 | 0.05 | 0.30 | 0.30 | 0 |

Table 20 Productivity of Crops Under Home Garden for village D. Kumbharbadi and Papikhunti

| | D. KUMBHARBADI | | | | PAPIKHUNTI | | | |
|---|---|---|---|---|---|---|---|---|
| | 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 | 0.607 | 0.165 | 0.165 | 0 | 6.558 | 2.56 | 0.46 | 2.1 |
| Tomato | 2.793 | 0.695 | 0.345 | 0.35 | 7.854 | 2.11 | 0.36 | 1.75 |
| Lady's Finger | 0.404 | 0.97 | 0.17 | 0.8 | 0.202 | 0.225 | 0.1 | 0.125 |
| Simba | 0.08 | 0.675 | 0.37 | 0.305 | 0.24 | 1.58 | 0.58 | 1 |
| Papaya | 0.08 | 0.90 | 0.90 | 0 | 0.24 | 0.5 | 0.5 | 0 |

# Discussion

Niyamgiri hills in Rayagada district have attracted many researches for the study of cultural and socio-economic life of Dongaria Kandha "Particularly Vulnerable Tribal Groups" (PVTG). The villages are surrounded by hilly forests of high altitudes and create micro-climatic effect in the locality. The economy is dependent on agriculture practice, MFP collections and to some extent animal husbandry. All the major activities of the village ecosystem were found to be linked to forest ecosystem directly or indirectly and are related to their socio economic and cultural traditions. Thus, forest is the rearing base of the tribal population and in turn the tribal pays tribute to the trees and mother earth in traditional worshiping process at the beginning of the cultivation, during crop cultivation and after harvest. Tribal communities have intricate linkages with natural forest to meet their basic needs of food and shelter. Commonly known as "ecosystem people" (Dasmann 1988) they depend on natural resources. Recent interventions by Government through various schemes have improved communication and education facility over the years. Dongaria Kandha Developing Agency (DKDA) is working towards improving the horticulture activity by providing seedlings, planting techniques and financial assistance. The village wise human population varies from 76(Papikhunti) to 312(Khajuri) with the average family size 3.8 to 5.1. All adult members of the family work in the field except older persons of age above 70. The male-female ratio varies from 1:1.04(Bhaliabhatta) to 1:1.59(Patlamba) except Papikhunti where the male population was more and male-female ratio was found to be 1:0.68. At the district level, male-female ratio is 1:1.028 as recorded in 2001 census and 1:1.051 in 2011 census.In our study, Patlamba village has the lowest family size of 3.8 which is greater than the family size of 3.6 of tribal villages of Ganjam district of Odisha (Nayak et al 1993). The highest value of family size 5.1 in village Khajuri is more than that of coastal villages (4.7) of state as reported by Sahoo and Mishra (1992).

The practice of agriculture under Podu cultivation, Mid hill orchards, home gardens and valley cultivations engage men and women about 8-9 months a year. The per capita agriculture land varies from 0.117 ha (Patlamba) to 0.329(D. Kumbharbadi). In uphill villages the Podu cultivation has major contribution than all other three categories of mid hill orchards, home garden and valley cultivation. In foothill villages the Podu cultivation area was slightly higher over valley cultivation except Bhaliabhatta where the valley cultivation (4.574ha) was more than Podu cultivation area(4.129ha).The average per capita cultivated area (0.117 ha) Patlamba was lower than the value (0.18 ha) reported for the Bhogibunda tribal village ecosystem (Nayak et al. 1993) and the average value (0.26 ha) for India (Ravelle, 1976).

The valley land area near perennial streams is usedfor cultivation, especially the paddy where good soil depth is available. The other three categories of agriculture practices i.e. uphill

Podu cultivation, Mid Hill orchard and home garden are under rain fed condition. As discussed about the location of the habitations, the forest ecosystem of dry deciduous tropical crop surrounds the habitation and helps in the perennial flow of streams. The four uphill villages focus on the Podu cultivationto produce minor Millet s like finger Millet , common Millet , pearl Millet and barnyard Millet with pulses like Red gram and Jhudanga (*Vigna*sp). The Mid Hill orchard provides fruits of Orange, Pineapple, Jackfruit and Mango for sale with cash crops of Turmeric and Ginger. Podu cultivation was traditional practice known as shifting cultivation as the tribal people used to shift to a new place periodically and then return. This land use pattern enhances soil erosion as the seeds and all growths cut and burnt before seeding. It is not an eco-friendly practice and gradually reduces forest cover butPodu activitiesare taken up manually and no tilling is done by draught animal prohibiting Carbon loss. Further, Podu cultivation of red gram (kandula) increases soil fertility by fixing atmospheric nitrogenbut reduces the area and quality of forest. Fertilizers, pesticide, irrigation or organic manure are not applied in Podu cultivation.Once some alternative is provided, Podu areas can be used for artificial regeneration of tree crops (Watson 1983, Akachkwa 1985, Ramakrishnan 1985).

Leaving crop residue in the field allows build-up of organic matter, thus, help building beneficial flora and fauna in soil.Organic farming is expanding rapidly and the process of transitioning from modern to organic agriculture may help to control pests biologically, manage nutrient cycles, produce different crops and tap new markets. However, in these villages, the Crop yields may not reach to a level to generate profits. Today also, the tribals are unable to get organic premiums while selling in local market due to lack of organic certification and market support. Hanson et al. (2004) suggested that subsidized crop insurance may be considered for farmers as the organic products market is increasing rapidly and some markets may be sensitive to oversupply and prices may be highly variable.

The production of minor Millet is prominent in uphill villages and productivity is higher than the district average productivity of 656 kg $ha^{-1}$(District Statistical Handbook 2011, Rayagada). The cause of higher productivity may be attributed to better soil fertility and cultural operations. Among the foothill villages, Millet productivityranged between 559 -794 kg $ha^{-1}$) which is at par with Rayagada district . Lower productivity in some foot hill villages maybe due to eroded soil cover with lower fertility. BarnyardMillet productivityranges from 633 kg $ha^{-1}$(Patlamba) to 803.71 kg $ha^{-1}$ (Rodanga). Well drained fertile soil with the effect of slash burning process before sowing of seed provides good growth and more productivity. Though records of comparison are not available, it can be considered in the line with finger Millet .PearlMillet is the mixed cropping system and productivity varies from 56.4 kg $ha^{-1}$ to 110.5 kg $ha^{-1}$. common Millet locally known as “Kangu” is added to the Podu cultivation mixed cropping where productivity value ranging from 87.82 kg $ha^{-1}$ to 424.45 kg $ha^{-1}$.The maize productivity in these

villages ranged between184 and 340 kg $ha^{-1}$across all villages except Papikhunti village with 1173.28 kg $ha^{-1}$, which is comparable to the District record of Rayagada 1112 kg $ha^{-1}$ in 2010-11 (District Statistics Handbook 2011).

India is the largest producer of Millet s in the world. Millets are cereals, contain more nutritious, proteins, minerals and vitamins compared to rice and wheat. Multiple varieties of Millets are produced in India such as Pearl Millet s, Sorghum, Finger Millet , Foxtail, Kodo, Barnyard, Proso, Little Millet and Pseudo Millet s like Buckwheat and Amaranths ( Pearl Millet (Bajra), Finger Millet (Ragi/Mandua), Minor Millet s i.e. Foxtail Millet (Kangani/Kakun), Barnyard Millet (Sawa/Sanwa/ Jhangora), Sorghum (Jowar), Proso Millet (Cheena), Kodo Millet (Kodo), Little Millet (Kutki) and two Pseudo Millet s (Buck-wheat (Kuttu) and Ameranthus (Chaulai). A natural source of iron, zinc, calcium and other nutrients and with higher content of folic acid, calcium, iron, potassium, magnesium, and zinc than rice and wheat, India's two varieties of Millets viz., Pearl Millet (Bajra) and Sorghum (Jowar) together contributed approx. 19 per cent of world production in 2020.. Finger Millet is the richest source of calcium (300- 370 mg/100 g). India's Pearl Millet production accounts for 40.51 per cent followed by Sorghum 8.09 per cent in the world production of Millet s in 2020. The major Millet producing states in India are Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Haryana, Gujarat, Madhya Pradesh, Tamil Nadu, Andhra Pradesh and Uttarakhand, together accounting for around 98 per cent ofMillet production in India during the period 2020-21. Six states namely Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Haryana and Gujarat accounts for more than 83 per cent share in total Millet production. Rajasthan contributes 28.61 per cent of the total Millet production in India. Pearl Millet (Bajra), Sorghum (Jowar) and Finger Millet (Ragi) constitutes the largest share in India's total production of Millet s. The estimated Millet yield in India has more than doubled since 1966. India's average yield in Millet farming (2021-22) is 1208 kgs per hectare. In 2021, approximately 12.3 kgs of Millet was available per person. In 2021-22, Pearl Millet contributed 58% to the total Millet production, followed by Sorghum (29%) and Finger Millet (10%).

The Indian government has also been promoting Millet production as part of its National Food Security Mission. Following 'International Year of the Millet', the India has started various activities and as a result, Millet production in India is expected to continue to grow in the coming years (APEDA 2022). The promotion of Millet for health benefits and as a sustainable crop will further contribute to improving nutrition, food security and the welfare of farmers. The villages of this study area have far lower productivity compared to productivity of finger Millet in other agriculture village ecosystem like Ungra (1.23 t $ha^{-1}$)as reported by Rabindranath et al (1981) and Bhabinarayanpur (1.08 t $ha^{-1}$) by Nisanka and Mishra (1990). Data on Jowar Millet production data in India revealed a production figure of 619-634 kg per ha in Odisha, 2689 in Andhra Pradesh and 1935 in Madhya Pradesh with all India average value of 1025 during 2017-

2021 (Directorate of Millets development, Jaipur). International Year of Millets (2023) proposed by India and endorsed by FAOand the 75th Session of the UN General Assembly will (i) elevate awareness of the contribution of Millet s for food security and nutrition (ii) inspire stakeholders on improving sustainable production and quality of Millet s; and (iii) draw focus for enhanced investment in research and development and extension services to achieve the other two aims. The Millets contain 7-12% protein, 2-5%fat, 65-75% carbohydrates and 15-20% dietary fibre. Around 40% of pre-schoolage children are suffering from the anaemia disease due to deficiency of iron in their body. It is also estimated that 250 to 500 thousand children go blind from Vitamin A deficiency every year. The consumption of Millets can effectively solve the problem of anaemia from the world (Rao et al 2017).

The large scale cultivation of Redgram, Jhudanga and Kating in Podu cultivation provides good economic return to the tribal community. Due to good market value most of the pulses were sold keeping small quantity for seed and domestic use. The Redgram grain productivity was found to be, 432- 1537 kg $ha^{-1}$ with lowest in Bhaliabhatta and highest in Papikhunti. The productivity in general is higher in uphill villages for their soil condition and intensive traditional care. Among foot hill villages Papikhunti villagers concentrate on Podu cultivation as they do not have paddy cultivation area and their land is suitable with good soil depth and soil fertility as observed in the field.Among other pulses, Jhudanga and Kating cultivation also provides sizeable cash economy to these tribal villages. The productivity of Jhudanga varies from 269 kg $ha^{-1}$ (Patlamba) to 1350 kg $ha^{-1}$ in Gortaliand of Kating varies from 331 kg $ha^{-1}$ (Rodanga) to 447 kg $ha^{-1}$ in Gortali. It is not cultivated in foothill villages.

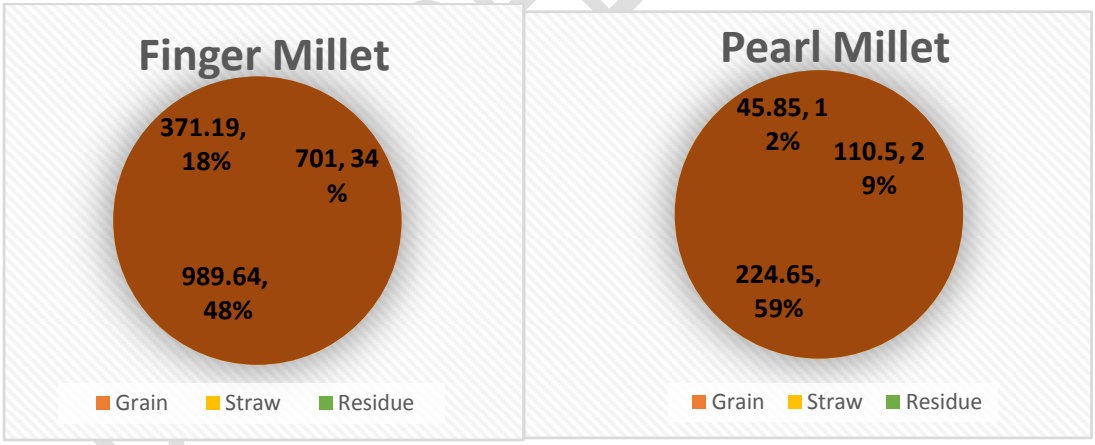
Two tier cropping pattern with fruit trees of Mango, Orange, Jackfruit, etc. with Pine apple, Turmeric, Ginger as under crops is followed in Mid hill orchards of villages. Almost all harvested crops are either sold in the fields or taken to the weekly market and normally the trading is done by the Scheduled Cast Communities, who do not work for agriculture operations. The absence of market support mechanism in these villages leads to meagre earnings as major profit of harvest goes to the trader instead of the real farmer, who invests lot of physical labour in adverse conditions. Lack of Storage facility also compels afarmer to dispose of the products soon after the harvest. Post- harvest management of crops or value addition support in villages can change the situation in favour of the farmer.Home garden involves the production of vegetables, maize etc. which was mostly used inside the village in uphill villages. Rarely some quantity is sold. But in foot hill villages surplus vegetables are sold in the local market. Papikhunti village recorded highest area under home-gardencultivation being nearer to market area for comfortable marketing avenue.

Paddy cultivation is done in only in one village (Rodanga) out of four uphill villages. The productivity of paddy was 2.424 t $ha^{-1}$ $yr^{-1}$which is far lowerthan the productivity at lower

elevation of Meghalaya 3.71 t ha-1yr-1 (Toky and Ramakrishnan 1981). The Paddy productivity in three villages (except village Papikhunti) ranged between 2.796 t ha-1yr-1 and 3.192 t ha-1yr-1 which is less than 4.70 t ha-1yr-1 for plain lands of Odisha (Nisanka and Misra, 1990). The lower productivity in both uphill and foothill villages can be attributed to the subsistence farming system followed by the tribal people without modern inputs. They depend on natural fertility of soil without adding any organic or in-organic manure. The seed input is also age-old local variety and the cultural operations are not followed properly.

**Impact of Straw and Residue Harvest**

Picture 17-21 and Picture 22 give a clear idea of how these villages are able to continue with this primitive agriculture system for so many years with subsistence productivity to meet their livelihood needs. Of all the Millet production in Patlamba village, grain constitutes 16-34%, the straw and the residue constitute respectively,48-67 and 12-19%, while grain constitutes 16-35%, the straw and the residue constitute respectively,49-68 and 10-20% in Rodanga village, grain constitutes 16-35%, the straw and the residue constitute respectively,48-65 and 14-19% in Khajuri village and grain constitutes 16-35%, straw and the residue respectively,47-68 and 14-19% in Gortali village of the total output. Therefore, almost one third of the Carbon and nutrients returned to soil in these cultivated areas of the villages. The residue harvest removes more nutrients from the agroecosystem than grain harvest alone.



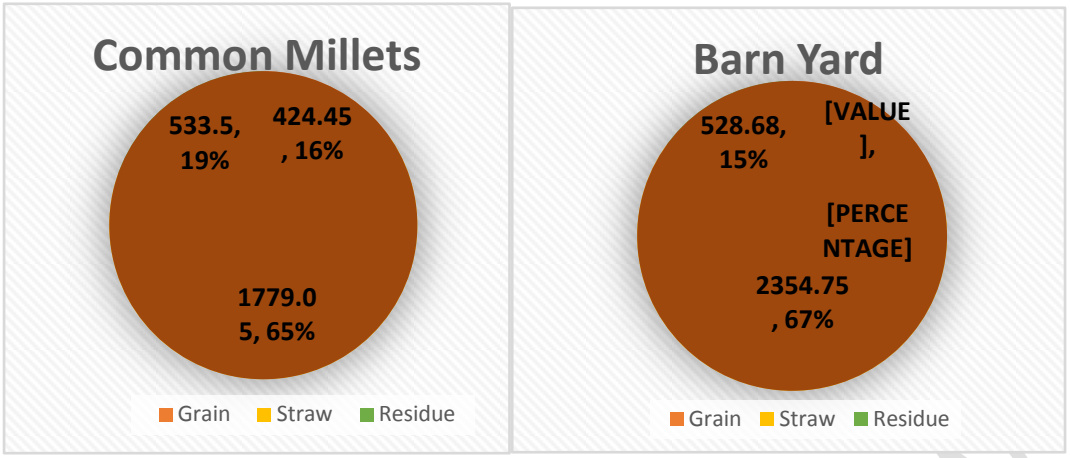
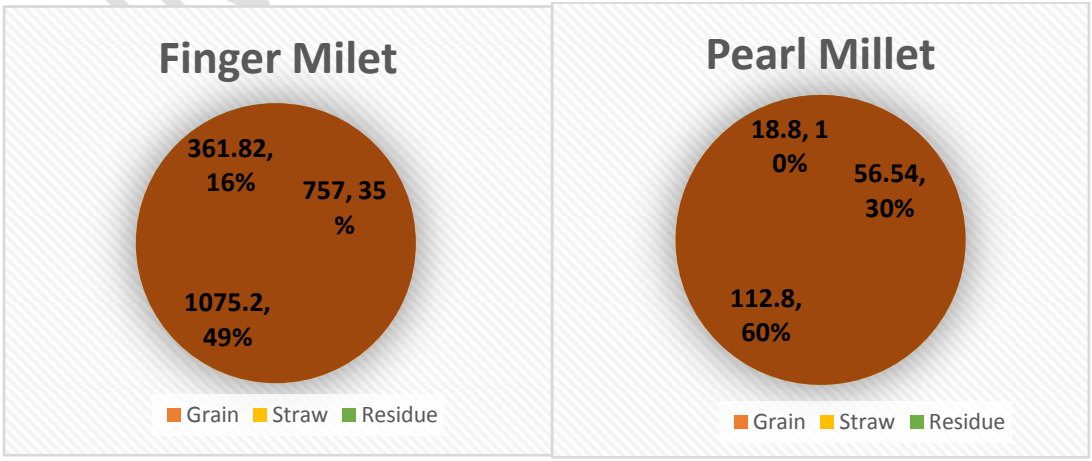



**Figure 17.** Grain**,** Straw and residue production (Kg $ha^{-1)}$ and proportionate contributions (%) in Harvested Millet s in village Patlamba

Holt (1979) predicted greatest loss from both residue removal and losses resulting from expected erosion increases with reduced soil cover. Lindstrom (1986) reported net losses of nutrients for high removal rates in no-till corn, suggesting that increased fertilization rates will be needed to maintain soil fertility. Increased crop yields was reported by Power et al. (1986) when residues were left on the soil surface compared with yields under residue removal. In the driest years, they observed that yield increases to residue-induced water conservation and recorded benefits from reduced erosion and increased soil organic matter Clapp et al. (2000) and Linden et al. (2000) found that production in residue-returned treatments exceeded those with no residue by approximately 22% in drier than average years. They also observed relationships between reduce tillage (chisel plow) and no-till cultivation.The study villages have been able to continue with agriculture activities mainly due to their traditional practice of leaving the residue in the field. That promotes regeneration of nutrients and moisture and also reduce soil erosion. Straw constitute 47-68% of the total production which is acting as mulching and nutrient amendment material in the field. Similarly the residue with 12-20% also increases the soil health to facilitates next crop productivity.





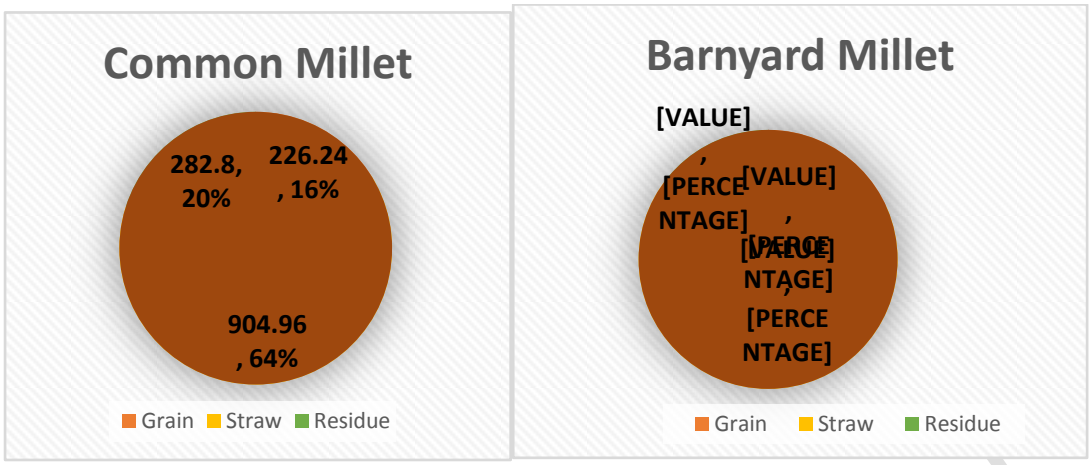



**Figure 18.** Grain**,** Straw and residue production (Kg $ha^{-1}$ ) and proportionate contributions (%) in Harvested Millet s in villageRodanga

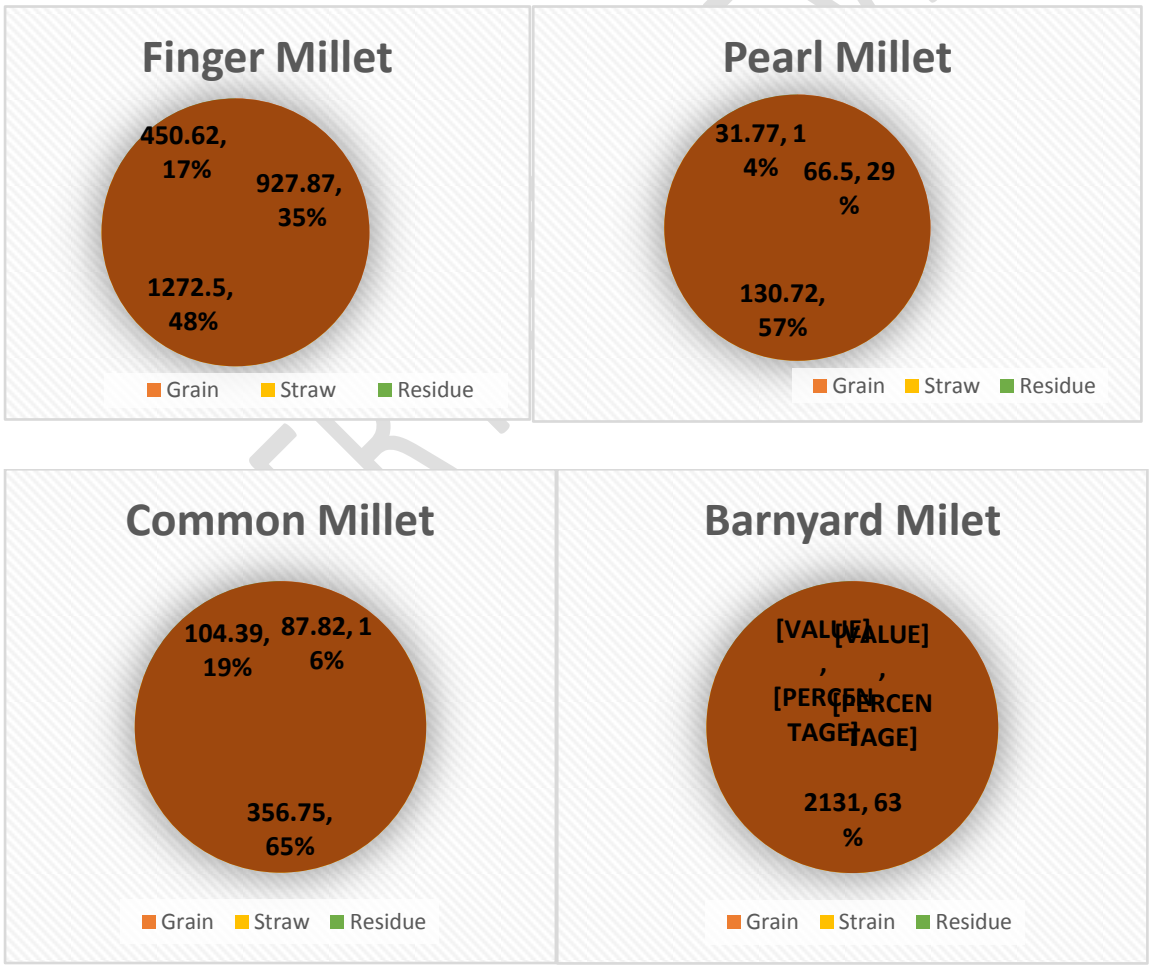



**Figure 19.** Grain**,** Straw and residue production (Kg $ha^{-1}$ ) and proportionate contributions (%) in Harvested Millet s in village Khajuri

Sauer et al. (1996) found that residue age and placement affect soil moisture and temperature and fresh residue, being thicker, provided more insulation and, therefore, reduced evaporation and Soil temperature due to surface reflectance than weathered residue and bare soil content (Benoit and Lindstrom, 1987). It is well concluded that residue removal results in increased erosion, reduced SOM and nutrient levels, and lower biotic activity that affect yield. The current practice of villagers also is a form of potential economic trade-offs that residue removal may require input higher fertilizer costs, reduced soil quality and soil organic matter (SOM).

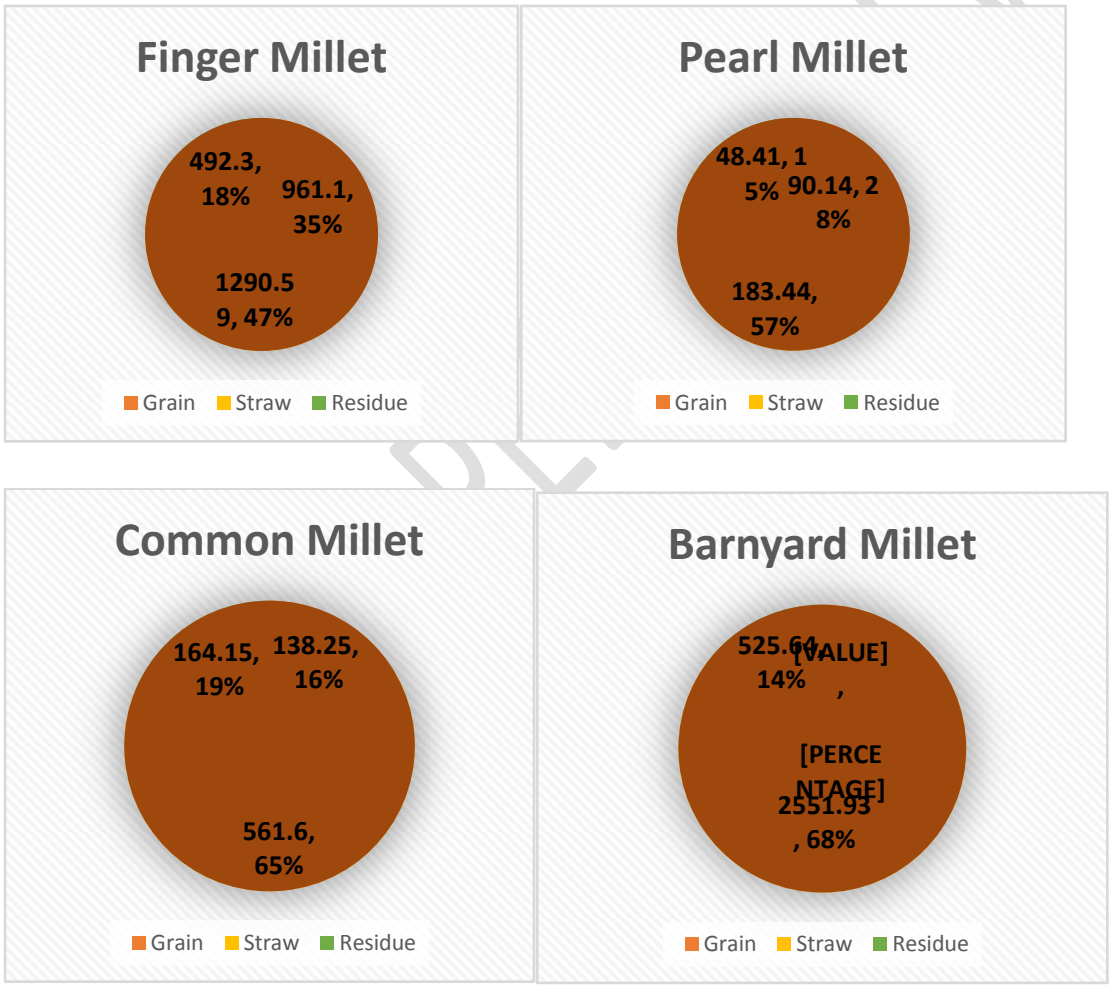



**Figure 20.** Grain**,** Straw and residue production (Kg $ha^{-1}$ ) and proportionate contributions (%) in Harvested Millet s in village Gortali

**Fodder Consumption**

The uphill villagers entirely depend on forest for feeding the animals of all category. The villagers provide shelter only to the cattle if available. But four villages at the foothill provide stall feeding besides grazing the animal in forest. Straw and other crop residue, husk and bran of grains are used as fodder and feed.Paddy straw, finger Millet straw, etc., bran and husk of grains, raw vegetable waste are given to animals as stall feed and fodder in foothill villages. Paddy straw consumption was 6.093 tons in Rodanga, 16.88 tons in Majhihalma, 14.537 in D. Kumbharbadi and 11.873 t in Bhaliabhatta (Table 21). Grasses and other green twigs have not been taken into account as stall feeding of grass was seldom practiced. Of all the Paddy production, while grain constitutes 60 %, the straw and the residue constitute respectively,35% and 5 % of the total output in four villages.

**Table 21**Rate of fodder consumption (Mg) in villages of Niyambiri hills

| Item | ***Villages*** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | P | R | K | G | M | B | D | H |
| Paddy Straw | - | 6.093 | - | - | 11.75 | 3.37 | 14.53 | - |
| Other Straw | 34.556 | 84.796 | 105.738 | 91.204 | 16.93 | 7.946 | 10.864 | 30.728 |
| Crop residue | 9.317 | 24.062 | 32.026 | 27.31 | 7.586 | 3.969 | 6.485 | 9.833 |
| *Note: P- Patlamba, R- Rodang ,K- Khajuri,G- Gortali, M- Majhihalma, B- Bhaliabhatta, D- D. Kumbharbhadi, H- Papikhunti* | | | | | | | | |

The trend of expanding crop biodiversity worldwide is now being reversed. The shift in agricultural production towards monoculture, and cash crop and distribution systems towards greater commercialization, increased technological inputs and globalization is associated with the rapid decline in crop biodiversity especially in tropical world which houses most of the biodiversity banks and germplasms. The magnitude of the loss is substantial i.e., thousands of rice varieties disappeared from Indonesia rapidly when the planting of local varieties was banned (El-Hage et al 2002). It is reported that over 10,000 varieties of wheat were grown in 1949 In China and that reduced by 90% by the 1970s (Tuxill,1999). This has happened in case of other major crops and fruit and vegetables all over the world.

The village sub-systems like agriculture, animal husbandry and domestic sub-system are inter-related with the forest ecosystem. The deficit of the village ecosystem is met either by meeting the needs from nearby forests or by procuring materials from outside these systems. The production of agriculture sub-system is not sufficient to meet the food requirement of villages ecosystem and Government supported PDS rice meet this gap. However, crops grown in other systems by villagers on the other hand, like horticulture products (Jackfruit, Pine apple, Banana,

Orange, Mango) 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.

Odisha Millet Mission (OMM) may need to provide interventions to these villages with modern approach to increase Millet productivity as Mission aims to revive Millet s on farms and plates with simultaneous focus on Production, Processing, Consumption, Marketing, and Inclusion of Millet s in Government schemes (Assocham, 2022). The program is to address the issues of food and nutrition security through the promotion of native Millet s. These villages qualify to be included in the overall objectives of OMM increasing productivity of Millet s crops through improved agronomic practices, increasing household consumption, setting up of processing units near villages, conservation and promotion of local varieties of crops and land races and better marketing of Millets through farmer producer organizations

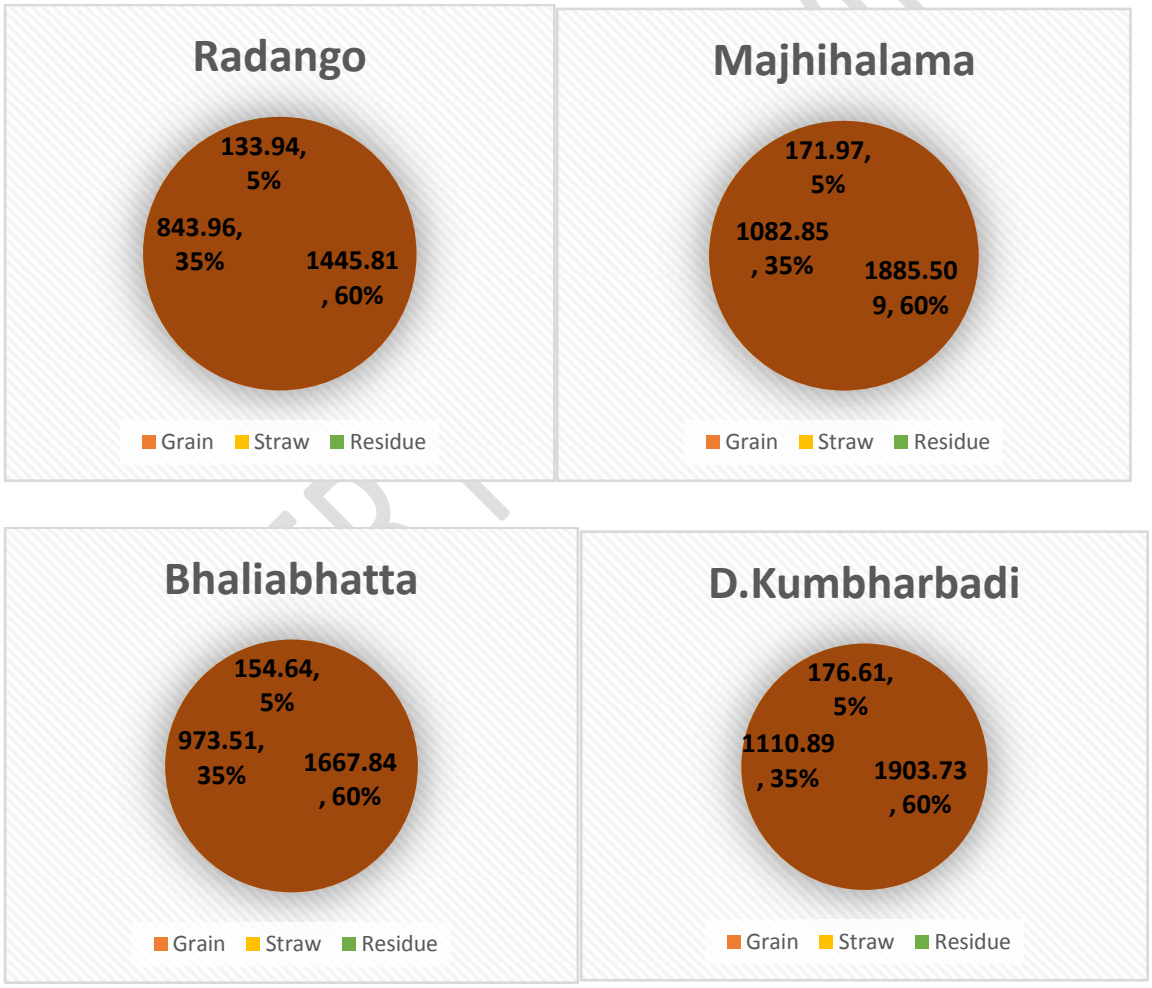



**Figure 21.** Grain**,** Straw and residue production (Kg $ha^{-1}$ ) and proportionate contributions (%) in Harvested Paddy in villages

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).

The Agro-ecosystem studies in central Himalaya 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 Similipal 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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