

Ecology of village ecosystems of Odisha, India

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Abstract. Upadhyay VP, Nayak BK, Mishra MK. 2022. Ecology of village ecosystems of Odisha, India. *Asian J Ethnobiol* 5: 138-155. The present study was conducted in eight villages in the Niyamgiri Hills of Odisha, India. The human population varies from 83 to 312 in uphill villages and 76 to 150 in foothill villages. The cultivated area constitutes 3.37% to 18.85% of the village's total area. Per capita cultivated area varies from 0.117 to 0.329 ha. The families generally devote more time to agriculture, followed by Minor Forest Products (MFP) collection. The women and children collect leafy vegetables, tubers, fruits, seeds, leaves, and flowers. Collecting and marketing firewood in head loads is commonly practiced in the rainy season. The area of forest cover is not affected much, but the quality of the forest has changed. This suggests appropriate steps to restore the forest and enhance its productivity. All villages depend on rain-fed agriculture. The natural stream water is available to the paddy fields by gravity flow in valleys. The agriculture practices include shifting (podu) cultivation in high hill areas, mid-hill orchards below the podu area, home gardens adjoining habitation, and valley cultivation near Nala beds (streams). Podu is a mixed cultivation practice where cereals, pulses, and oil seeds are grown together. The village productivity is much lower than in other areas of settled agriculture. Improvements in seed quality, Soil and Moisture Conservation (SMC) measures, and the health condition of the tribal community will help support the sustainability of the traditional cultivation and livelihood system. To help protect the indigenous biodiversity, we suggest in this paper other alternatives of livelihood to the local population and options for shifting cultivation areas.

Keywords: Common property resource, forest, livelihood minor forest produce, Niyamgiri, Odisha, podu cultivation, tribal

INTRODUCTION

The practice of conversion of natural tropical forests to agriculture by landless people is prevalent in many countries (Anderson 1990; Schenldar 1995). The ecosystem is dynamic, and we need to adopt model cultivation practices in tropical areas to counter the adverse impact of the converted ecosystem (FAO 1993; Aida et al. 2016). The human-environment relationship can be studied at the socio-economic and cultural levels, emphasizing the production and consumption of biomass energy and highlighting the developmental opportunities existing within the ecosystem (Sahoo and Misra 1992; Rao et al. 2003). A tribal village is considered an ecosystem by considering its biomass production, consumption, and energy dynamics in terms of import and export (Nisanka and Misra 1990; Nayak et al. 1993). In India, the tribal village ecosystem functions mainly by recycling resources within the system (Mishra and Ramakrishnan 1982.). Biomass energy and human labor are two main driving forces for the functioning of an agriculture-based village ecosystem (Nisanka and Misra 1989; Rao et al. 2000). There have been efforts by ecologists to correlate the changes in plant-animal diversity with different scales of natural/anthropogenic disturbances (Van Der Maarel 1993; Nautiyal et al. 2003; Maikhuri et al. 2004). The agroecosystem concept provides a framework to analyze the food production system as a whole, including its complex set of inputs and outputs and the interconnection (Gliessman 2007). Traditional agriculture is comparable to

natural ecosystems, not only in physical structure but also in terms of an organic environment, disease resistance, higher biodiversity, and stability. Even if it is a rain-fed condition, its sustainability is proven over centuries. Small tropical farmers without the knowledge of taxonomy unknowingly conserve biodiversity, indirectly contributing priceless donations to the gene pool. These are extremely poor people whose livelihood depends on the vast, diverse, and risk-prone marginal environment (Conway 1997). An ecological approach is needed to develop a system and technology that suits small farmers' specific environmental and socio-economic conditions without increasing risk or dependence on external inputs. Agroecosystems should be resource-conserving yet highly productive systems such as polyculture, agroforestry, and integration of crops and livestock (Altieri 1995). Traditional resource management adaptations such as agroforestry systems may provide options for livelihood improvements through the simultaneous production of food, fodder, and firewood, as well as mitigation of the impact of climate change (Rabindranath and Hall 1995).

More diverse agroecosystems have better control over pests and diseases through the favorable environment for the natural enemies of pests and resistance of different species to the spread of disease (Landis et al. 2000). Monoculture, with reduced structural and functional diversity has low resiliency than natural ecosystems. Growing demand for food coupled with land and water management practices that cause degradation and erode natural resource bases simultaneously put sustainable

pressure on the ecosystem services (Abel et al. 2003). Bennett et al. (2005) pointed out that with the growing demand for food production and water use, demands for other ecosystem services, in many cases, will be beyond the capacity of certain ecosystems to supply. The planners have to assess the production of various services in the ecosystem on the one hand and the social and economic benefit and the risk of using technology to provide them on the other (Bennett et al. 2005). Scientists have evolved diverse agroecosystems, some of which are rich in biodiversity and provide ecosystem services, including food production (Jarvis et al. 2007). Agroforestry system may provide part of the answer to the challenge of sustainability on how to conserve forest ecosystem and farmland biodiversity as well as services they provide, including enhancing food production for an increasing population under the condition of land and water scarcity (Godfray et al. 2010; Lambin and Meyfroidt 2011; Phalan et al. 2011). A more biologically complex system will provide short and long-term environmental and socio-economic benefits, or ecosystem services, such as enhanced food security and agricultural resilience to environmental change (Altieri 1980; Tomich et al. 2011).

In the present study, we conducted research in eight villages closely connected to the natural ecosystem and where social activities and ecological processes are closely interrelated. The results presented here include an in-depth analysis of human-ecosystem functioning and benefits derived by the society including biomass used as food, fuel, fiber and construction materials. Thus, this case study aimed at gathering information on agroecosystem functioning around Niyamgiri Forests to address the above issues and to suggest how conservation objectives can be achieved by making village ecosystem compatible to ecological requirements. The main objective of the present program was to study the village ecosystem in and around Niyamgiri Hill Forest with an integrated view of all conditions and influences. Furthermore, the sustainability of the agroecosystem, its dependency on the forest ecosystem, and the community's economic development were studied in terms of resource management.

MATERIALS AND METHODS

Study area and environment

There are about 164 villages in and around Niyamgiri Hill Range, India, deriving their livelihood from forest resources. The practice and traditional agriculture in the vicinity are prehistoric. However, the magnitude of changes in the inter-dependency of agroecosystem and forest ecosystems has led to ecological and economic deterioration. Therefore, studies of ecosystem linkages and socio-cultural changes are essential to developing a strategy to arrest further degradation of the ecosystem and suggest priority sectors for improvement. The study sites are located around Niyamgiri Hill Ranges in four blocks (Figure 1). Eight villages were selected for the study, out of which four village settlements are situated at higher elevations inside Niyamgiri Forest, and four village

settlements at the foothill, out of which two are closer to the marketplace (urban area) and two are a little away from the urban area. The village settlements are Villages inside Niyamgiri Hill Forest at higher altitudes: Patlamba, Khajuri (Figure 2), Rodanga (Figure 3), Gortali; Villages outside the Niyamgiri hills away from the marketplace (Majhihalma, Bhaliabhata); and Villages outside the Niyamgiri hills nearer to the market place (D. Kumbharbadi, Papikhunti).

Niyamgiri forest lies between 83°17' to 83°29' E Long and 19°02' to 19°42' N Lat. Most of the forest remains un-surveyed due to inaccessibility. Only a few Reserve Forest (RF) and Proposed Reserve Forest (PRF) exist in the Niyamgiri Hill Range, covering 125.86 sq. km (Tables 1 and 2). Varied topography with continuous valleys and ridges and unbroken mantle of forest supports very rich biodiversity, involving tropical and sub-tropical species. It is the cradle of major rivers of Rayagada District, with Bansadhara in the north and Nagabali in the south, which flows to the Bay of Bengal through Andhra Pradesh, Niyamgiri Hill Forest is elongated in a north-south direction (ca 36 km) with an average width of about 15 km and encompasses about 496 sq km area. The altitudinal variation is from 400 m to 1516 m, responsible for varied vegetation, higher rainfall, and cooler micro-climate with perennial streams. Niyamgiri hill range is an extensive area with degraded *Shorea robusta* (sal) forest interrupted by shifting (*podu*) cultivation practices in the habitation areas. Inhabitants in the range are the Kandha Tribe, namely 'Dongria Kandha'- a primitive tribal group settled near perennial streams in high altitude areas (600-700 m). In the region, the microclimate effect is revealed with a cooler climate, more rainfall than adjoining areas and rich biodiversity. Difficult terrain footpaths connect the settlements. All weather roads are a recent development to peripheral villages otherwise, the vast tract of land is almost virgin. Shifting cultivation provides food and fodder to the people, and the forest provides additional support with tubers, fruits, and leafy vegetables besides fuel wood, housing materials, agriculture implement and grazing land.

Climate

The monthly variation in temperature indicates seasonal changes (Table 3). Three seasons are distinct. The minimum temperature was recorded during January (6.2°C) and the maximum temperature during June (45.6°C). Niyamgiri hill ranges experience a monsoon climate from mid-May to mid-October which is more than the 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 (Table 4). The rainfall spreading over five months creates a micro-climate in the area which has highly diverse vegetation. Most streams are perennial in nature, and the inhabitants use the water for domestic purposes and irrigation. The forest vegetation is miscellaneous, with intermittent sal forest with its associates. The relative humidity observed at 8.30 AM and 5.30 PM indicates the climatic status of the locality. The monthly average relative humidity information recorded for the district is presented in Table 5.

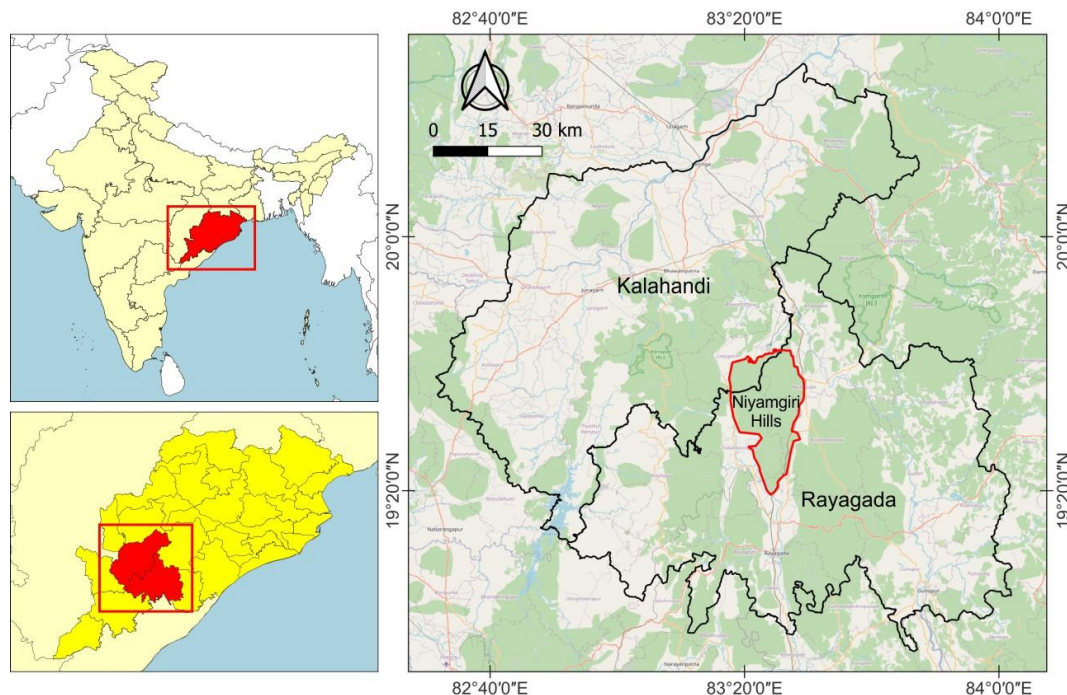


Figure 1. Location of Niyamgiri Hills in the District of Rayagada and Kalahandi, India



Figure 2. Uphill Village Khajuri, India



Figure 3. Common Worship place of Village Rodanga, India

Table 1. Reserve Forest (RF) and Proposed Reserve Forest (PRF) area in the Niyamgiri Hill, India (Source: Rayagada and Kalahandi (s) Forest Divisions)

Name of RF/PRF	Area (ha)	Remarks
Khambasi PRF	693.00	Muniguda range, Rayagada District
Niyamgiri PRF	2810.93	K. Singhpur range (total area= 6124.58 ha)
Karanja RF	607.29	Rayagada District
Kansaralu RF	839.56	
Kansaralu extn RF	105.26	
K.Singhpur RF	323.88	
Sajja PRF	1236.03	
Satabisi PRF	201.62	
Niyamgiri RF	2100.00	Biswanathpur range (total area= 5768.65 ha)
Tiramunhi PRF	536.65	Kalahandi District
Nachinigurah RF	1298.00	
Jalakrirha RF	1834.00	

Table 2. GPS location of studied villages at Niyamgiri, Odisha

Name of villages	Latitude	Longitude	Alt. (m)	Remark
Patlamba	19° 29' 2''	83° 25' 51''	550	Inside villages of Niyamgiri at higher elevation
Khajuri	19° 30' 1''	83° 25' 44''	687	
Gartali	19° 30' 57''	83° 26' 3''	812	
Rodanga	19° 29' 28''	83° 25' 27''	647	
Kumbharbadi	19° 28' 36''	83° 26' 54''	435	Outside villages at foot hills
Papikhunti	19° 27' 42''	83° 26' 39''	419	
Majhialma	19° 27' 39''	83° 26' 40''	411	
Bhalibhatta	19° 28' 24''	83° 27' 10''	423	

Table 3. Annual temperature (°C) at Niyamgiri during 2009 to 2013

	2009		2010		2011		2012		2013	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
January	6.7	32.3	6.5	31.2	6.2	34.1	6.8	33.2	6.3	31
February	11.5	33	10	37	11.2	29.1	10.5	36	10	34.2
March	14	42	16	41.2	15	40	15.5	42.2	16.2	42
April	21	41.5	22	44	20	40.5	21.5	43	20.2	43.6
May	22.5	44.2	23.5	45.5	21.5	43.5	22	44.5	24	45
June	21.2	43	20.2	45.6	24	41	23	45	21.5	44.2
July	22.2	35	23.2	35.5	21.5	36	21.5	34.5	22	37
August	23.5	36	23.2	35.2	23	35	22.2	36.5	23.2	35.2
September	20	34.5	20	34.2	21.5	34.2	20.5	33	21	33.5
October	16	35.6	17	34.2	15.5	35.6	16	34	16.5	35
November	14.5	33.5	16	33	12.5	34	13	32	15	34
December	8	30	7.7	31.1	7.8	32.2	7.2	30.2	7.5	31.2
Annual	6.7	44.2	6.5	45.6	6.2	43.5	5.8	44.5	6.3	44.2

Table 4. Annual average rainfall (mm) and rainy days

	2009	2010	2011	2012	2013
January	0	31.90	0	20.07	0.6
February	29.2	0	20.7	2.3	8.1
March	1.0	3.2	0.6	1.37	1.5
April	90.9	24.8	23.59	12.25	54.4
May	74.2	97.7	20.99	8.21	9.5
June	200.5	144.6	177.64	214.95	170.45
July	155.8	392.5	219.71	335.69	318.77
August	350.8	313.8	279.11	205.94	295.16
September	248.4	215.6	234.7	221.29	133.85
October	14.5	179.5	34.02	48.2	152.97
November	0.0	43.3	0.1	47.37	1.8
December	0.5	44.5	2.5	0	0
Total	1165.8	1491.4	1013.66	1117.64	1147.1

Table 5. Relative humidity (%) changes during the year in study region of Niyamgiri Hills, India

	2009	2010	2011	2012	2013
January	63	67	58	67	64
February	51	51	61	52	56
March	41	43	49	40	42
April	43	47	59	47	49
May	51	54	48	46	49
June	54	64	66	58	69
July	85	85	74	77	75
August	83	81	81	80	78
September	79	82	79	79	78
October	70	81	74	73	84
November	79	82	71	72	69
December	70	71	68	62	65

Methodology for study

Data on the socio-ecological structure and functioning of eight villages were collected through questionnaire-cum-schedule method (Mitchell 1979; Nisanka and Misra 1990; Nayak et al. 1993; Sahoo 1993). These publications were considered while preparing the questionnaire and collecting socio-economic and ecological data of the selected villages during 2010-2015. The boundaries of the villages were defined with the help of the state revenue map. The sampled villages were visited regularly for data collection based on the inhabitants' availability. The survey information was collected by interviewing the family heads. In addition, sample weighing of humans, animals, and materials was done in the field.

Human population and socio-economic structure

The human population was calculated from the total family members of the villages. The literacy rate was determined by interviewing the heads of the family. The questionnaire forms were filled up by getting information from the family heads about their occupation, source of income, materials used in day-to-day life and construction of houses, cultivation and agricultural products, market, and sale of available surplus products after self-use, etc. Land ownership determines the status of the family in the

tribal villages. Since shifting cultivation is commonly practiced in hilly tracks, the information on shifting cultivation was collected in detail through field visits, the inputs and outputs for different crops were recorded, including home garden and valley cultivation. The horticulture products that support most families' economies are orange, pineapple, banana, mango, litchi, etc. The crop residues used as soil fertilizer or fuel wood were also recorded. In addition, the annual production of dung used as organic fertilizer was recorded.

Forest resources, plant biomass and productivity

The community's dependency on the forest was evaluated by collecting information on minor forest produce and varieties of food products derived from the forest. The requirement of small timber, firewood, bamboo, etc., for the house construction, is also noted. The production of the sap of *Caryota* palm was estimated from the persons collecting the sap during the winter season. The above-ground biomass of crops grown in shifting cultivation areas, home gardens and valley areas was estimated in the field at harvest time. The biomass of individual crops raised by the villagers was measured at harvest time, and the 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 the average productivity of the village. The surplus agricultural products are normally sold in the nearest weekly market (Chatikona). The villagers meet the market demand for different forest produce every week or when required. This provides economic support and eligibility to purchase his/her family requirement from the market. The information on villagers' sales and purchase of different commodities was recorded. Domestic animals like cows, buffalo, goats, sheep, and pigs are commonly kept by villagers, along with local poultry varieties. The information collected through the questionnaire was recorded.

Among the forest produce, fuel wood and fodder are major biomass components followed by a small timber, bamboo, and food products (tubers, seed, fruit, leafy vegetables, etc.). Individual household data collected from each village were consolidated for comparison. The food consumption was calculated depending on the total production for agriculture, forest animal husbandry, etc., excluding the products sold in the weekly market or village itself as surplus only. The food grain, vegetables, etc., purchased from the weekly market or public Distribution System (PDS) was added to the quantity consumed. In agriculture, the crops are produced in different seasons. The grains and residues were sampled to assess the total production. Tubers and leafy vegetables are collected during the rainy season before the crops are harvested. This was estimated by family-wise daily collection, which is rarely sold, almost all consumed. Domestic animals like cattle, goats, sheep, buffalo, etc., graze in the adjoining forest. No stall-feed is provided. The quantity of fodder consumed was assessed by the intake capacity of animals based on average body weight. The quantity of fuel used in a family was estimated by head load-wise consumption for several days. The average head load weight was measured and given to different family-sized households (family members) in each village to estimate different consumption rates. Kerosene was given through PDS in a monthly quota used in the family. The sap of *Caryota* palm (salapa) is collected locally by limited members of the villagers and sold locally. The quantity of liquor production was estimated by the number of fully grown plants present in the village area. The collection period starts after the rainy season and continues through winter up to summer. The consumption rate was estimated by counting the number of individuals using the salapa sap and the quantity of sap produced. Elderly persons commonly use black cigars from the Tobacco leaf grown in the village. It is grown in the periphery villages of Niyamagiri, but not uphill villages inside Niyamagiri and is used by both male and female adults. The uphill villager does not grow Tobacco but purchases it from the weekly market. Women more commonly use black cigars.

Waste of biomass and material flow

The crop residue left in the field was collected in a sample area and weighed to assess the total residue left in

the fields. The use of fodder and grain by birds, rodents, insects, etc., was not considered. The materials sold /exported by villagers and purchased from the outside market were recorded through a questionnaire by contacting each family. The self-sufficiency of the ecosystem was calculated based on the import/ export data of individual villages. Total hours spent for each crop were calculated considering the respective crop area. Total human hours (men, women, and children) spent on the collection of minor forest products were estimated by counting the hours spent per day by individuals of each category and the total collection days during the year. This was based on the information collected from family heads and weekly observations. Participatory Rural Appraisal (PRA) method was used to study villages' status of Common Property Resource (CPR). The objective of studying the status of CPR was to understand the functioning of traditional society living in village clusters i.e., the traditional land management practice for agriculture and animal husbandry, the interdependence of forest and other land management systems and the role of CPR in making the village self-sufficient.

RESULTS AND DISCUSSION

The villages under study are located in forest pockets in such a manner that the hilly topography and vegetation demarcate their boundaries. The villages are widely separated from each other, perhaps to avoid conflicts on natural resources available in the forest ecosystem. However, the forests beyond the boundary were used for shifting cultivation and collection of minor forest produce. This boundary extends up to the point of activity of the inhabitants. Structural components of the village ecosystem and various socio-economic factors were individually surveyed for ecological studies. The structural analysis mainly includes land use patterns, population and practices, housing patterns, and physical resource bases of the villages. The geographic area of the 8 villages is presented in Table 6 with the break-up of components under housing and cultivation (home garden, shifting cultivation and valley cultivation). Per head cultivated area varies by 0.117 ha (Patlamba) to 0.329 ha (D. Kumbharabadi). Shifting cultivation is prominent in four villages in the upper hill area (i.e., Patlamba, Rhodanga, Khajuri, and Gortali). The forest area is utilized for shifting cultivation and home garden. Paddy cultivation is observed in one upper hill village (Rhodanga) and three-foot hill villages (Majhihalma, Bhaliabhata, and D. Kumbharabadi).

Human population and literacy

The human populations of villages were calculated from the household survey of family details. The male-female ratio indicates the female population is bigger in all villages except Papikhunti. The ratio is higher in four hilly villages, where male persons die at lower age as reported by old persons. The average family size varies from 3.8 to 5.2. The literacy rate varies widely from 4.8% in Patlamba to 72% in D. Kumbharabadi. Elder persons above the age

group of 40 years are totally illiterate in uphill villages. Only in recent years have schooling facilities developed. Adults aged 25-30 years have some primary education (Table 7).

Land use pattern and land ownership

The topography plays a major role in the land use by villages. Easy gradient slopes with soil cover are mostly used for raising crops under shifting cultivation. This provides basic food to the communities. It is always a polyculture type with temporal and spatial arrangements. Complex cropping is a traditional practice with many ecological and economic advantages. It is locally known as “Dongar” cultivation. All cereals, pulses, and oil seeds are grown here. It is only in rain-fed conditions. The second category of land is the valley area known as “Gudia” or “Padar” which is mostly used for ginger and turmeric, with some fruit plants surrounding the field or cottage. The land is mostly used for different cash crops like banana, orange, mango, litchi, jackfruit, etc.

The third category of land used for cultivation is the Nala-beds / aquatic areas with a perennial water flow mostly used for paddy. The low-elevation villages in the periphery of Niyamgiri practice paddy cultivation using stream water in very small patches with all uncertainty. Continuous rainfall in hilly areas promotes speedy flow in Nala-beds, at times washing all crops. Thus, three major categories of land are available for agricultural use. The homestead area of villages is very small, with compact

houses in rows facing each other with a commonplace. The aquatic area is limited to the flow of mostly perennial streams. The major common property resource is forest land and uncultivated area. Nowadays, bore-well has been provided to the villages for drinking water. But the practice of using Nala water for all purposes is still prevalent. In some places, Dongaria Kandha Development Agency (DKDA) has provided an irrigation facility for horticulture crops. The clean stream water is supplied to the urban community at Bissam-Cuttack through gravity flow at a distance of about 10-12 km.

The area of the villages/settlements, as in official records, has little relevance to the use by the village community. The ‘Dongaria’ community of the hills does not feel the differential use of Government or private land. According to the ownership of the land area, the families of each village are grouped into four categories, i.e., (i) landless, (ii) Less than one ha, (iii) between 1-2 ha, and (iv) more than 2 Ha. These classifications are based on the revenue records with the forest right area of the families (Tables 8 and 9). The uphill villagers mostly use Government Forest lands for shifting cultivation and horticulture crops, which has no relationship with the above classifications. The foothill villagers are mostly restricted within the revenue-recorded land and rarely use forest land for raising crops. Unlike foothill villages, the uphill families have been given forest right titles under Forest Right Act.

Table 6. Structural analysis of village ecosystem

Village data	Villages							
	P	R	K	G	M	B	D	H
Total household	22	60	61	39	36	18	26	16
Total human population	83	279	312	201	150	90	100	76
Total male	32	129	140	87	72	44	47	45
Total female	51	150	172	114	78	46	53	31
Male: female	1:1.59	1:1.16	1:1.22	1:1.31	1:1.08	1:1.04	1:1.12	1:0.68
Average family size	3.8	4.65	5.1	5.2	4.2	5.0	3.8	4.8
Literacy rate (%)	4.8	21.86	39.4	13.9	48.0	21.1	72.0	50.0
Total livestock population	200	218	334	383	341	112	131	176
Cow	4	16	22	25	39	0	29	21
Bullock	0	6	0	0	0	19	0	6
Buffalo	0	7	0	0	0	7	0	16
Goat	83	51	67	86	78	13	42	26
Sheep	0	33	0	0	0	0	0	2
Poultry	90	90	77	173	140	73	37	99
Pig	23	15	168	99	84	0	23	6
Land use pattern								
Total land area (ha)	157.97	297.75	307.66	259.23	624.17	60.61	250.16	173.72
Aquatic	0	0	1.15	0	0	0.52	2.12	0
Housing	0.06	0.29	0.36	0.36	0.33	0.40	0.17	0.16
Up hill shifting cultivation	5.46	13.52	19.14	14.21	9.028	4.129	7.854	7.328
Mid hill (orchard)	3.1	27.83	36.68	20.43	0.1	0.04	0.1	0.06
Home garden (vegetables)	0.61	5.18	3.24	3.04	8.06	3.40	7.11	15.20
Valley paddy	0	7.22	0	0	10.84	3.46	13.07	0.00
Valley maize	0.566	1.235	10.809	9.514	8.016	4.574	4.777	0.554
Per capita agricultural land orchard (ha)	0.117	0.197	0.223	0.234	0.240	0.173	0.329	0.304

Notes: P: Patlamba, R: Rodanga, K: Khajuri, G: Gortali, M: Majhialma, B: Bhaliabhata, D: D. kumbharbadi, H: Papikhunti

Table 7. Distribution of households according to land holding capacity in Patlamba, Rodanga, Khajuri and Gortali ecosystems, India

Occupation	Village ecosystems			
	Patlamba	Rodanga	Khajuri	Gortali
Landless	1	25	-	3
< 1 ha	11	14	15	9
1-2 ha	10	14	32	12
> 2 ha	-	7	14	15
Total	22	60	61	39

Occupational status and household

The houses are constructed in rows facing each other in a commonplace. The house is now AC-sheet/G.I sheet roofed under different schemes, and the use of wild straw has been discontinued. Almost all houses are now pucca for living. The village goddess is worshiped in the middle of the commonplace between the house rows. The animals have separate sheds. Houses are open to the front and back sides without windows or chimneys. A narrow verandah exits on the front side of each house. Separate houses exist for young unmarried boys and girls, known as "Dhangada House." This is a part of their culture. All households of these villages use aluminum and earthen pots. The villagers invariably use Siali and Sal leaf plates and cups. These Tribals use traditional fuel-inefficient mud stoves for cooking.

Socio-economic status

All families of Patlamba are economically backward in comparison to other villages. Traditionally the villagers depend on forests and valleys for their livelihood, but forest degradation has threatened the community for the non-availability of various forest products. Most forests are open and biotic pressure does not allow these to regenerate naturally. As a result, biodiversity has been affected adversely, and many common minor forest products have become rare and threatened. The shifting cultivation area, which is naturally fertile with forest nutrients, provides economic support to the families. The agricultural products obtained are kept for domestic use first, and then the balance is sold in the weekly market. Seasonal products like wild mango, jackfruit, jamun, wild tubers, leafy vegetables, and tamarind are marketed in the weekly market and the nearest Railway Station of Bissam-Cuttack. Truckloads of green jack fruits (for vegetable purposes) are

Table 9. Occupational status of household in the Uphill Villages, India

Occupation	Villages			
	Patlamba	Rodanga	Khajuri	Gortali
Cultivation	-	-	-	-
Daily wage earner	-	-	-	-
Cultivation + wage earner	22	48	61	39
Animal grazer	-	-	-	-
Carpentry	-	-	-	-
Business	-	12	-	-
Ideal, getting old age pension	-	-	-	-
Total	22	60	61	39

Table 8. Distribution of households according to land holding capacity in Majhihalma, Bhaliabhata, D. Kumbharbadi and Papikhunti ecosystems, India

Occupation	Village ecosystems			
	Majhihalma	Bhaliabhata	D.Kumbharbadi	Papikhunti
Landless	30	14	6	7
< 1 ha	4	0	9	6
1-2 ha	0	2	8	2
> 2 ha	2	2	3	1
Total	36	18	26	16

exported to the neighboring states of Chhattisgarh and Andhra Pradesh during January and February. The delicious and large-size jamuns are exported by rail to distant places, which fetch good market value. Siali leaves are collected from the forests and made into leaf plates for marketing. Among the agricultural products, turmeric and ginger are produced commercially, which meets the major family expenses. With the Dongaria Kandha Development Agency (DKDA) initiative, large-scale pineapple cultivation with mango, orange, and litchi has started, providing a good annual income for the family.

Occupation

Shifting cultivation is the major occupation in the uphill areas of "Niyamagiri," whereas the foothill villages practice normal cultivation. The villages like Patlamba, Rodanga, Khajuri, and Gortali have the practice of helping each other in agriculture work in the "Bhuti" system. In this system, all households will depute a worker to work in the field of one family for a day, which is treated as one "Bhuti." The cost of one "Bhuti" is a nominal price, much less than the wage and the benefitted family will pay it to the common village fund. The foothill villages like Majhihalma, Bhaliabata, D.Kumbharbadi and Papikhunti also work as daily wage labor besides cultivation. Though the scheduled tribe community dominates all the villages, the marketing of agricultural products commercially is only conducted by the few members of the scheduled caste community. Collection of minor forest produce from the adjoining villages by the women members and minor children provides off-time engagement in all villages. Collecting firewood (Figure 4.A) for self-use and marketing is a day-to-day practice of the uphill villages (Tables 9 and 10).

Table 10. Occupational status of household in the foothill villages studied

Occupation	Villages			
	Majhihalma	Bhaliabhata	D.Kumbharbadi	Papikhunti
Cultivation	-	-	-	-
Daily wage earner	-	-	-	-
Cultivation + wage earner	28	15	26	14
Animal grazer	-	-	-	-
Carpentry	-	-	-	-
Business	8	3	-	2
Ideal, getting old age pension	-	-	-	-
Total	36	18	26	16

Table 11. Animal resources (number of animals) in uphill villages

Animals	Patlamba	Rhodanga	Khajuri	Gortali
Goat	83	51	67	86
Sheep	0	33	0	0
Pig	23	15	168	99
Cattle	4	23	22	25
Buffalo	0	6	0	0
Poultry	90	90	77	173

The details of the livestock population (2010-2011) are given in Tables 11 and 12. We recorded the maximum goat population in Gortali (86) and the minimum in Bhaliabhata (13). The number of Pigs is highest in Khajuri (168) and lowest in Papikhunti (6), with no pigs in Bhaliabata. The cattle population varies from 4 to 25 in hilly areas inside Niyamagiri Forest and 7 to 39 in bordering villages. Cattle is neither used in agriculture nor milk production in uphill villages, but the foothill villages in the periphery use these animals as drought animals and in the production of milk. It is the source of cow-dung manure for agricultural purposes. Poultry was present in almost all families.

Marketing and marketable surplus products

The Bissam-Cuttack Railway Station and the weekly market of Chatikona are the major marketing area of the villages taken up for the study. The daily consumables are purchased from the weekly market of Chatikona on Wednesday, but the sale of marketable surplus, mainly mango, pineapple, jackfruit, orange, and banana, is done at the railway platform of Bissam-Cuttack Station. The rice and kerosene of the public distribution system are received from Chatikona. Due to the improvement of road communication, the light vehicles reached the village site to purchase jackfruit and pineapple, which are produced in large quantities. The weekly market also provides scope for the sale of minor forest produce like tubers, siali leaf plates, and horticulture products. However, the villages do not have shops to meet their domestic requirement. Therefore, a barter system is still prevailing in the villages, either through vendors or direct transactions.

Physical resource base

The local production systems together form the physical resource base of the villages. These fall into five major sub-systems, i.e., (i) Minor Forest Products, (ii) Valley Agriculture, (iii) Shifting Cultivation, (iv) Home Garden, and (v) Animal Husbandry. The resource bases which are responsible for village ecosystem function are discussed separately under different heads. Forest in and around villages is a major Common Property Resource (CPR) besides the grazing land, road, water sources (*Nala*), etc. The use of the forest for shifting cultivation is an age-old process, an unrecorded right that is socially accepted by the village community. The forest area, excluding the shifting cultivation sites, forms the CPR for all households of the Schedule Tribe category. The Schedule Caste households, wherever present, are not allowed to occupy land in the Government Forest area. A few Schedule Caste households

Table 12. Animal resources (number of animals) of studied foothill villages

Animals	Majhialma	Bhaliabhata	D. Kumbharbadi	Papikhunti
Goat	78	13	42	26
Sheep	0	0	0	2
Pig	84	0	23	6
Cattle	39	7	29	34
Buffalo	0	19	0	9
Poultry	140	73	37	99

have a Revenue Record of Right but do not go for cultivation. Instead, they are involved in the marketing business of agricultural products produced by the Schedule Tribe households. Since the forest area is vast and the population is very much restricted to small pockets, there is no conflict in the collection of Minor Forest Produce (MFP) (Table 13).

Besides shifting cultivation areas, every household has developed orchards in lower hill areas by planting mango, orange, litchi, banana, etc., which is in forest area and excluded from CPR. Ginger and turmeric are valuable cash crops and contribute to the family's major income. The forest adjoining villages are degraded miscellaneous species in composition and the soil erosion is prominent due to hilly topography. Lacking fertile soil and humus has led to poor regeneration capacity and low productivity. Accordingly, the quality, quantity, and variety of MFP available are reduced yearly. The practice of shifting cultivation by the Dongaria Tribe has also affected the vegetation cover and surface soil. Despite the reduced availability of Different Forests Produce (CPR), the sharing habit is strongly accepted by society without any internal dispute. The practice of agriculture and collecting Firewood and MFP (bamboo, siali leaves, wild tubers, mango, jackfruit, and tamarind) control the village's household economy. An in-depth study of the CPR system is essential for understanding the function of a tribal village ecosystem.

Participatory rural appraisal

All households were allowed to participate in the PRA exercise to express their views on the resource base of the village, its present use, and proposed improvement for the community. The information on the natural resources like forests, water sources, and land resources was recorded to prepare the village-wise information sheet for the present study. During the study, the villagers were interviewed about the status of CPR. Everybody was allowed to give his impression about the status. The persons were also interviewed in separate groups to know the priority of different forest products available to them in their village site. As a result, the forest area is given priority among different CPRs like grazing land, water bodies, roads, etc.

Community forest

The uphill and foothill villages depend on the forest for firewood, bamboo, small timber, etc. The uphill villagers are involved in large-scale shifting cultivation, whereas the foothill villagers depend on normal agriculture practices. The uphill villagers inhabit small pockets with forest cover

on all sides, whereas the forest has receded to distant places from the foothill villages. The forest in both areas has been degraded due to over-exploitation during the last 40 years, which the elderly persons from the community informed. The forest was dense with wildlife populations, even with the highest predatory animal (tigers). The increasing demand for timber, house construction, and the poor economic condition of local inhabitants are the important reasons for felling trees. The fruit-bearing trees like mahua, mango, tamarind, jamun, and char are protected besides *Caryota* palm, which provides *Caryota* sap.

In 1988 the Government of Odisha assigned Forest Protection Activity to the adjoining village community by forming the Village Forest Protection Committee (VFPC). The foothill villagers were involved in forest protection, as they have limited resources (forest area), but the uphill villagers did not pay attention as they have plenty of forest area. Gradually over the years, the Government policy changed to facilitate several benefits to the village community through Joint Forest Management Committee (JFMC) with a resolution in 1993. This resolution has also undergone various amendments during 2008, 2011, and 2015 to meet the changing requirement of the Forest and Community.

Annual collection of Minor Forest Products (MFP)

The collection of MFP is a traditional practice of all villages in a forest area. Besides the adult male and female members, children of all age groups participate in different activities of the collection process as per their ability. All products collected from forests, excluding timber, firewood, and bamboo, are treated as MFP (Figures 4.A-I). After the Government Resolution of the year 2000, the collection right of MFP is given to the public, which can be collected by a registered agent of Gram Panchayat with the market price fixed in the Panchayat Samiti. For the source of MFP, the forest and village community are closely associated over generations. MFP meets the daily requirement of many commodities necessary for the day-to-day life of Tribals. The surplus MFP is exported from the villages. The MFP collected by the tribal people of the villages during 2010-2011 is given in Tables 14, 15 and 16.

Forest and local products

The mahua tree (*Madhuca latifoila*) is an economic species for the forest fringe villagers and is mostly worshiped in various ways. The mahua (or mahula in local dialects) flowers are collected during March and April for domestic consumption and commercial use in preparing country liquor. Mahula trees provide oil seeds collected during May and June for the cooking and burning purposes of the tribal communities. Mahula trees are well distributed in foothill villages and very rarely seen in uphill areas. The tamarind (*Tamarindus indicus*) trees grow in the wild and are protected by villagers for the collection of tamarind. These trees are very few and are the villagers' common property. Most of the quantity collected is sold in the weekly market at Chatikona to meet the market expenses for domestic purchases of the tribal people. Siali (*Bauhinia valichii*) leaves are collected by women members and stitched to plates (khali) and cups (dana) for selling in the weekly market. The collection is taken up during August and September, which is an idle period for agricultural activities. Bamboo is a common agricultural material for fencing and roofing work in the village area. A limited number of people takes up a collection of bamboo from the forest for domestic and marketing purpose. The young shoots of bamboo (karadi) are collected for self-use and export purposes during the rainy season. This is used as vegetables in many parts of the district. The alcohol produced from *Caryota* palm (salapa) is collected by a limited number of persons from adult plants of *Caryota* palm. It is collected during winter and summer seasons and sold in the village area. *Caryota* palm is distributed in a limited village area; thus, the production of *Caryota* sap is limited. This sap is a nutritious food for the tribal people. This sap extracted during the day is generally consumed on the same day. During the peak period of sap production, Tribals of the nearby villages shared the sap by coming over to the place of production. Although the sap is generally consumed three times a day, they took it when required, as the sap production continued up to the end of the season.

Table 13. Production/ collection of Minor Forest Produce (MFP) in the villages (Mg village⁻¹ yr⁻¹)

Item	P	R	K	G	M	B	D	H
Bamboo	42.4	34.6	30.8	17.3	18.3	8.5	13.8	7.5
Broom grass	0.19	0.38	0.45	0.4	0.3	0.25	0.2	0.15
Mahua flowers	0.09	-	-	-	-	-	-	-
Sap of <i>Caryota</i>	0.26	4	5.05	3.3	-	-	-	-
Leafy Vegetables	0.51	0.77	0.75	0.56	0.21	0.12	0.11	0.15
Siali Leaf	0	0.161	0.176	0.85	-	-	-	-
Tamarind	0.155	0.35	0.32	0.25	0.05	0.03	0.05	0.03
Miscellaneous fruits	0.153	-	-	-	-	-	-	-
Wild tubers	0.925	2.385	2.705	1.56	-	-	-	-
mango	4.48	48.3	56.92	26.75	-	-	-	-
Small timber/ Pole	33.02	18.7	16.75	11.7	10.05	5.65	6.4	5
Amla	0.22	-	-	-	-	-	-	-
Fire wood	253.2	419	426	226.5	259	106.5	197	101.5

Note: Average weight of bamboo taken as 20 kg each; Siali leaf plate bundle (100nos) taken as 350gm average; Weight of each pole taken as 10 kg



Figure 4. A. Firewood collection from forest, B. Marketing of pineapple, C. Young shoots of bamboo (Karadi), D. *Caryota* palm, E. Jackfruit at Niyamgiri, India, F. Hill broom, G. Jamun fruit, H. Collection of wild mango, I. Siali leaf pots

The villagers use the thatch grass to thatch their huts for themselves and domestic animals. Gradually over years, different projects have been taken up in the areas, especially after Dongoria Kandha Development Agency (DKDA) was established in 1978 to provide support for the livelihood of these Particularly Vulnerable Tribe Groups (PVTG). As a result, the roof structure changed from traditional thatched roofs to G.I. or A.C. sheet roofs. Thus, the use of thatch grass to make roofs has been abandoned and is rarely seen in uphill villages, only for domestic animal huts, etc. Broom grass naturally occurs in moist areas, especially the Nala sides, which flowers during winter, and the sticks (inflorescence stalks) are collected during January and February for use as broomsticks. Therefore, it is very common in uphill areas and rarely found in foothill areas. The annual collection is made to usable broom sizes and sold in the weekly market. Domestic consumption is very little. The average village-wise collection is 355 kg in the uphill areas and 225 kg in the foothill villages (Tables 15 and 16).

Wild mango is collected from the green stage to mature condition for marketing in the weekly market or Railway station area. It provides jobs for about three months. The collection of jackfruits in the early stage for vegetable purposes provides a large-scale market to the community. It is exported by rail and road, providing good annual income to the villagers of uphill areas. The jamun (*Eugenia jambolana*) fruit is unique in this area for its attractive size and taste. It is marketed to the outside areas of different States, providing a good economy to the locality. Among other fruits, tamarind, kendu, bhalia, khajur, etc., are commonly collected for self-use and marketing. The common leafy vegetables are *Bauhinia*, *Amaranthus*, and *Marsilea*, with many more varieties collected in different seasons. *Bauhinia* is the most frequently used leafy vegetable, collected to 3180 kg annually by all the villagers. Other Minor Forest Products include Myrobalans, wild tubers, etc., which are collected in small quantities, having less impact on the rural economy. Edible mushrooms and *Bauhinia* seeds are also collected from the forests for domestic use.

Table 14. Production, consumption and export of Minor Forest Products (MFP) in Village Patlamba, Rodanga and Khajuri, India

Minor Forest Products	Patlamba			Rodanga			Khajuri		
	Collection	Consumption	Export	Collection	Consumption	Export	Collection	Consumption	Export
Bamboo (<i>Dendrocalamus strictus</i>)	42.4	2.2	40.2	34.6	30.4	4.2	30.8	30.0	0.8
Broom grass	0.19	0.04	0.150	0.38	0.060	0.320	0.45	0.070	0.380
Mahua flower	0.09	0.03	0.060	-	-	-	-	-	-
Sap of caryota palm	0.26	0.00	0.180	4.00	0.390	3.610	5.05	1.180	3.870
Leafy vegetables	0.51	0.26	0.250	0.77	0.400	0.370	0.75	0.250	0.500
Siali leaf	-	-	-	0.161	-	0.161	0.176	-	0.176
Tamarind	0.155	0.04	0.115	0.35	0.050	0.300	0.32	0.060	0.260
Misc. fruits	0.153	0.153	-	-	-	-	-	-	-
Wild tubers	0.925	0.925	-	2.385	2.385	-	2.705	2.705	-
Mango (wild)	4.48	0.42	4.06	48.3	7.180	41.12	56.92	9.96	46.96
Small timber/poles	33.02	1.78	31.24	1.870	1.590	0.280	1.675	1.675	-
Amla	0.220	-	0.220	-	-	-	-	-	-
Wild date	-	-	-	-	-	-	-	-	-
Firewood	253.2	89.6	163.6	419	186.35	232.65	426	346	80
Total	335.603	95.528	240.075	511.816	228.805	283.011	524.846	391.90	133.146

Note: Average weight of bamboo taken as 20 kg each; Siali leaf plate bundle (100nos) taken as 350gm average; Weight of each pole taken as 10 kg

Table 15. Production, consumption and export of Minor Forest Products (MFP) in Village Gortali, Majhihalma and Bhaliabhatta, India

Minor Forest Products	Gortali			Majhihalma			Bhaliabhatta		
	Collection	Consumption	Export	Collection	Consumption	Export	Collection	Consumption	Export
Bamboo	17.3	17.3	-	18.3	17.5	0.8	8.5	8.5	-
Broom grass	0.400	0.060	0.340	0.300	0.060	0.240	0.250	0.050	0.200
Mahua flower)	-	-	-	-	-	-	-	-	-
Sap of caryota palm	3.300	0.740	2.560	-	-	-	-	-	-
Leafy Vegetables	0.560	0.260	0.300	0.210	0.050	0.160	0.120	0.030	0.090
Siali leaf (No of plates)	0.85	-	0.85	-	-	-	-	-	-
Tamarind	0.250	0.050	0.200	0.050	0.050	-	0.030	0.030	-
Misc fruits	-	-	-	-	-	-	-	-	-
Wild tubers	1.560	1.560	-	-	-	-	-	-	-
Mango (wild)	26.750	4.250	22.50	-	-	-	-	-	-
Small timber/poles	1.170	1.170	-	1.005	1.005	0	0.565	0.565	-
Amla	-	-	-	-	-	-	-	-	-
Wild date	-	-	-	-	-	-	-	-	-
Firewood	226.50	177.50	49.00	259.00	208.50	50.50	106.50	83.50	23.00
Total	278.64	202.89	75.75	278.86	227.165	51.70	115.96	92.675	23.29

Note: Average weight of bamboo taken as 20 kg each; Siali leaf plate bundle (100nos) taken as 350gm average; Weight of each pole taken as 10 kg

Table 16. Production, consumption and export of Minor Forest Products (MFP) in the village D. Kumbharbadi and Papikhunti, India

Minor Forest Products	D. Kumbharbadi			Papikhunti		
	Collection	Consumption	Export	Collection	Consumption	Export
Bamboo	13.8	13.0	0.8	7.5	7.5	-
Broom grass	0.200	0.050	0.150	0.150	0.050	0.100
Mahua flower	-	-	-	-	-	-
Sap of caryota palm	-	-	-	-	-	-
Leafy vegetables	0.110	0.110	-	0.150	0.040	0.110
Siali leaf	-	-	-	-	-	-
Tamarind	0.050	0.050	-	0.030	0.030	-
Misc. fruits	-	-	-	-	-	-
Wild tubers	-	-	-	-	-	-
Mango (wild)	-	-	-	-	-	-
Small timber/poles	0.640	0.640	-	0.500	0.500	-
Amla	-	-	-	-	-	-
Wild date	0.095	0.045	0.050	-	-	-
Firewood	197.000	158.500	38.500	101.500	81.500	20.000
Total	211.895	172.395	39.50	109.83	89.62	20.21

Note: Average weight of bamboo taken as 20 kg each; siali leaf plate bundle (100nos) taken as 350gm average, weight of each pole taken as 10 kg

The sustainability issue of the Niyamgiri ecosystem has been in public debate for a long time due to proposed policies to start mining activities in the region. Niyamgiri hills in Rayagada district attracted much research for Dongria Kandha “Particularly Vulnerable Tribal Groups” (PVTG) for their socio-economic and cultural traditions. The villages are surrounded by hilly forests of high altitudes, creating a micro-climatic effect in the locality. The economy is dependent on agriculture, MFP collections, and to some extent, animal husbandry. The village ecosystem’s major activities were directly or indirectly linked to the forest ecosystem directly or indirectly. Thus, the forest is the rearing base of the tribal, and the tribal, in return, pays tribute to the trees and mother earth in the traditional worshipping process at the beginning of the cultivation, during crop cultivation, and after harvest.

Structure of village ecosystem

Tribal communities prefer natural forest pockets to meet their basic needs of food and shelter. Commonly known as “ecosystem people” (Dasmann 1988), they depend on natural resources and, unlike urban people, they do not expect beyond their reach. Government schemes have improved communication and education facilities over the years. Dongria Kandha Developing Agency (DKDA) also helped to improve the horticulture activity by providing seedlings, planting techniques, and financial assistance. The traditional thatched roof has been changed to A.C. Sheet/G.I Sheet roofs, and in almost all villages, “Indira awas” houses have been provided to the families. The village-wise human population varies from 76 (Papikhunti) to 312 (Khajuri), with an average family size of 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 (Bhaliabhata) to 1:1.59 (Patlamba) except in Papikhunti, where the male population was higher, i.e., 1:0.68. In the district-level male-female ratio, Rayagada recorded 1:1.028 in the 2001 census and 1:1.051 in the 2011 census. The literacy rate

was found to be lowest at Patlamba (4.8%) and highest at D. Kumbharbadi (72%), which is comparable to the state literacy rate of 72.9% (Census 2011). The literacy rate of Rayagada District in 2011 was recorded as 49.8%. The school-going children are deviated to agriculture and animal husbandry work, reducing the literacy rate. The low literacy rate was due to the traditional practice of domestic work and the lack of infrastructure for schooling. The villagers had no communication facility for the students to attend school in the hilly forest areas. The D. Kumbharbadi, the foothill village and nearer to urban places with schooling facilities, has the highest literacy rate. But now the education facility has improved and girl students also are motivated by the Government to attend school. Patlamba village has the lowest family size of 3.8, which was greater than the family size of 3.6 of tribal villages of the Gajam District of Odisha (Nayak et al. 1993). The highest family size, i.e., 5.1 in village Khajuri is more than that of coastal villages, 4.7 (Sahoo and Mishra 1992). Lack of education and awareness has affected the socio-economic status adversely, and the use of alcohol has reduced the working ability of the population. Almost all adults in the uphill villages are illiterate. Due to the improvement in schooling facilities and motivation, the children are attending schools. Recently, DKDA has focused on educating the girl students by providing residential school facilities.

The practice of agriculture under Podu cultivation, mid-hill orchards, home gardens, and valley cultivations involved men and women for about 8-9 months a year. The collection of minor forest products provides work for 3-4 months a year. Firewood collection is one of the important components of a forest ecosystem. The per capita agriculture land varies from 0.117 ha (Patlamba) to 0.329 (D. Kumbharbadi). In uphill villages, podu cultivation contributes more significantly than all the other three categories. In foothill villages, the podu cultivation area was slightly higher over valley cultivation except in Bhaliabhata, where the valley cultivation (4.574 ha) was

more than the podu cultivation area (4.129 ha). The average per capita cultivated area (0.117 ha) in Patlamba was lower than in Bhogibunda (0.18 ha) village (Nayak et al. 1993) and the average value (0.26 ha) for India (Ravelle 1976).

Agriculture sub-system

The perennial streams are used in valley cultivation, especially the paddy with good soil depth. The other three categories of agriculture practices, i.e., podu cultivation, mid-hill orchard and home garden, are under rain-fed conditions. The dry deciduous tropical forest ecosystem surrounds the habitation and helps in the perennial flow of streams. The four uphill villages focus on podu cultivation and mid-hill orchard. Podu cultivation is done for minor millets like finger millet, common millet, pearl millet, and barnyard millet, with pulses like redgram and jhudanga (*Vigna* sp.). The mid-hill orchard provides orange, pineapple, jackfruit, and mango fruits for sale, with cash crops of turmeric and ginger. Podu cultivation is a 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 seedlings and all growths are cut and burned before seeding. Thus, it is not an eco-friendly practice and gradually reduces forest cover. Podu cultivation reduces soil fertility, which farmers leave for several years to allow it to regain its fertility by the natural process of soil cover growing out of existing rootstock and weeds. In podu cultivation, all activities are done manually and no tilling is possible by draught animals. The podu area is normally near the village boundary at high hill altitudes. The cultivation of red gram (kandula) increases soil fertility by fixing atmospheric nitrogen. Podu cultivation gradually reduces the area and quality of the forest for which it has been suggested for artificial regeneration of tree crops (Watson 1983; Akachukwa 1985; Ramakrishnan 1985). Since the requirement of the Tribal community is multiple products, food production through site-specific agroforestry models can meet the day-to-day family requirement.

In tribal villages, where the geography is undulating in nature, agriculture depends on human energy and, to some extent, draught animals. In developing countries, agriculture operations mainly depend on human energy and animal energy (Hall et al. 1982). The uphill villages depend entirely on human labor, whereas the foothill villages depend on human and animal energy. Bullock is preferred over buffalos for agriculture operations. Fertilizers, pesticides, irrigation, and organic manure are not used in podu cultivation. Podu cultivation is practiced in high hill areas, mostly inside forest boundaries. The Asian Rural Life Foundation Philippines has developed different models for these areas with a common name of SALT (Sloping Agriculture Land Technology), which is suitable for the geographic and adaptive conditions and able to meet the socio-economic need of the community. The SALT-2 model was tagged with livestock and SALT-3 refers to an integrated system of Agroforestry. Fixation of atmospheric Nitrogen can improve the soil status, leading to better

crops. The choice of species for different components is more important for a successful model.

The production of minor millet is prominent in uphill villages. Four categories of millets, different pulses, and oil seeds were grown on the same plot in Podu cultivation. The productivity of finger millet grain was 701 kg ha⁻¹ in Patlamba, 757 kg ha⁻¹ in Rodango, 927.87 in kg ha⁻¹ Khajuri and 961.1 kg ha⁻¹ in Gortali, where millet was widely used. All the above value of productivity is higher than the average district productivity of 656 kg ha⁻¹ (District Statistical Hand Book Raygada 2011). The cause of higher productivity may be attributed to better soil fertility and cultural operations. Among the foothill villages, higher productivity was recorded for Majhihalma (794.10 kg ha⁻¹) and Bhaliabhatta (660.8 kg ha⁻¹) whereas D. Kumbharbadi (562.72 kg ha⁻¹) and Papikhunti (559.15 kg ha⁻¹) have productivity at par with Raygada district record of 656 kg ha⁻¹. Lower productivity in foothill villages may be due to eroded soil cover with lower fertility. On the other hand, the productivity of finger millet in other settled village ecosystems, such as Ungra (1.23 t ha⁻¹) and Bhabinarayanpur (1.08 t ha⁻¹), is much higher (Nisanka and Mishra 1990).

Barnyard millet is another important product for food in uphill villages. All four uphill villages and Papikhunti of foothill village take up its cultivation with production value ranging 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 comparison records are not available, it can be considered in line with finger millet. Pearl millet is a mixed cropping system that has low share and productivity, which varies from 56.4 kg ha⁻¹ (Rodanga) to 110.5 kg ha⁻¹ (Patlamba). It is locally known as "Ghantia" and no records are available for comparison. Similarly, another kind of millet, commonly millet locally known as "kangu," is partially added to the podu cultivation mixed cropping. It has a productivity value ranging from 87.82 kg ha⁻¹ (Khajuri) to 424.45 kg ha⁻¹ in Patlamba. The normal practice of planting maize is in rows at certain intervals. Only the Village Papikhunti had the practice of planting in blocks. The productivity in these villages was 220 kg ha⁻¹ in Patlamba, 340 kg ha⁻¹ in Rodanga, 203.5 kg ha⁻¹ in Khajuri, 184.9 kg ha⁻¹ in Gortali, 193.3 kg ha⁻¹ in Majhihalma, 190.2 kg ha⁻¹ in Bhaliabhatta, 184.21 kg ha⁻¹ in D. Kumbharbadi. The productivity of maize in Papikhunti was 1173.28 kg ha⁻¹, which is comparable to the district record of Raygada, i.e., 1112 kg ha⁻¹ in 2010-2011 (District Statistical Hand Book Raygada 2011).

The large-scale cultivation of redgram, jhudanga, and kating in podu cultivation provides a good economic return to the tribal community. Due to the good market value, most pulses were sold, keeping small quantities for seed and annual domestic use. The redgram grain productivity was 826 kg ha⁻¹ in Patlamba, 995 kg ha⁻¹ in Rodanga, 1072 kg ha⁻¹ in Khajuri, 1236 kg ha⁻¹ in Gortali, 702 kg ha⁻¹ in Majhihalma, 844 kg ha⁻¹ in Bhaliabhatta, 432 kg ha⁻¹ in D. Kumbharbadi and 1537 kg ha⁻¹ in Papikhunti. The productivity, in general, is higher in uphill villages due to

their soil condition and traditional intensive care. Among foothill villages, Papikhunti villagers concentrate on Podu cultivation as they do not have a paddy cultivation area and their suitable land with good soil depth and soil fertility as observed in the field. Among other pulses, jhudanga and kating cultivation also provide a sizeable cash economy to these tribal villages. The productivity of jhudanga varies from 269 kg ha⁻¹ (Patlamba) to 1350 kg ha⁻¹ in Gortali village. The productivity of kating varies from 331 kg ha⁻¹ (Rodanga) to 447 kg ha⁻¹ in Gortali, and it is not cultivated in foothill villages.

Mid-hill orchards are two tiers cropping patterns with fruit trees of mango, orange, jackfruit, etc., with pineapple, turmeric, and ginger as under crops. Almost all crops are cash crops. The harvested crops are sold in the fields or taken to the weekly market. Normally, the scheduled cast communities do the trading, who do not go for agriculture operations. The major harvest profit goes to the trader instead of the real farmers, who invest a lot of physical labor in adverse conditions. The farmers are compelled to dispose of the products soon after the harvest due to a lack of storage facilities. Post-harvest management of crops or value addition can change the situation in favor of the farmers. Home gardening involves the production of vegetables, maize, etc., which is practiced and consumed inside the village in uphill villages and rarely some quantity was sold. But in foothill villages, surplus vegetables are sold in the local market. Papikhunti village recorded the highest area under the home garden. The village is nearer to the market area and thus marketing was easier. Paddy cultivation was taken up in one village (Rodanga) out of four uphill villages under study. The productivity of paddy was 2.424 t ha⁻¹yr⁻¹. The productivity is lower than the productivity for the lower elevation of Meghalaya, 3.71 t ha⁻¹yr⁻¹ (Toky and Ramakrishnan 1981). Three villages in the foothill area take up paddy cultivation, except for the village of Papikhunti. The Paddy productivity was 3.11 t ha⁻¹yr⁻¹ in Majhihalma, 2.796 t ha⁻¹yr⁻¹ in Bhaliabhatta and 3.192 t ha⁻¹yr⁻¹ in D. Kumbharbadi. The highest productivity of D. Kumbharbadi is less than 4.70 t ha⁻¹yr⁻¹ from the plain lands of Odisha (Nisanka and Misra 1990). The lower productivity in uphill and foothill villages can be attributed to the subsistence farming system followed by the tribal people. They depend on soil's natural fertility without adding any organic or inorganic manure. The seed input is also an age-old local variety and the cultural operations are not followed properly.

Animal husbandry sub-system

Animal husbandry is a practice only by tradition. The family head has not given the rearing importance. The old woman or young boys and girls take the herd to the forest for feeding. The fodder availability changes with a monsoon. The uphill villages neither go for milk collection nor use draught power. Animals and poultry birds are used for worship offerings in different functions. In other hilly areas of India, where land availability for green fodder is more, people invest in livestock though agriculture land availability is limited (Moench 1989). The ratio of the

human population to livestock population varies from 1:0.43 (Bhaliabhatta) to 1:1.34 (Majhihalma), which indicates a poor population compared to other tribal villages of the State. Nisanka and Misra (1990) reported the average human and livestock animal ratio as 1:0.96 in an agricultural village. Four villages were found to be above average value (Patlamba, Gortali, Majhihalma, and Papikhunti) and the other four villages (Rodanga, Khajuri, Bhaliabhatta, D. Kumbharbadi) were below it. The human and livestock ratio has been reported by Sukla and Pandey (1993) for tribal villages of Madhya Pradesh as 1:1.05, whereas Nayak et al. (1993) reported the ratio as 1:0.67 for tribal villages in Odisha. The scrub cattle population carelessly moves into forest areas and takes shelter in villages. The main economy may be the collection of dung during shelter time which is used in home gardens and valley cultivation. However, foothill villages are better animal husbandry managers, and few families take care of cows and buffalo and collect milk for sale. Dung is collected and taken to valley cultivation after decomposition. In all villages, there is scope to improve animal husbandry. Eastern Ghats' dry tropical areas are comparable to humid tropical areas where animal husbandry is a low-cost sub-system (Payne 1985). This is because of the easy availability of natural resources in the humid tropics (Gomez-Pompa et al. 1972) and lesser population pressure as in the Northeastern hill region (Ramakrishnan 1985). Some have adopted swine rearing for its low-cost management and rapid population increase, leading to a better return.

Forest products

Minor Forest Product (MFP) has developed a socio-economic link between forest and village ecosystems. The adaptations for collecting MFP and the poverty of villages have led to easy access to forest natural resources. Besides the highly valuable intangible benefit of a clean environment, the forest provides food, fuel, and fodder for the village ecosystem. The shifting cultivation lands on hill slopes with little soil cover meet the daily need of the family. This process of shifting cultivation gradually reduces the soil depth and soil quality which affects productivity.

Besides MFP, the villagers collect bamboo, fuel wood and miscellaneous poles for use in the village and sale in the local market to meet family expenses. Few people in the uphill villages have the routine practice of collecting and selling firewood and bamboo in the market. Aged persons from the local forest area the collection of firewood. Bamboo is collected from distant places because it is not available in the nearby areas for which young people do the work. The maximum number of bamboo collected by Patlamba was 2120 stems in a year, followed by Rodanga (1730), Khajuri (1500) and Gortali (865) in uphill villages. Among the foothill villages, a maximum number of bamboo was collected by Majhihalma (915), followed by D. Kumbharbadi (690), Bhaliabhatta (425), and Papikhunti (375). Majhihalma villagers have more vegetable areas and use more bamboo for support etc.

Wild mango collection and sale at Bissam Cuttack Railway Station provides about three-month summer engagement to the uphill villagers. Young and old persons move along the Nala sides, and the collection starts from the green stage of mango until full ripening. The only investment is human labor and the green mango usually sells at Rs. 2/- to Rs. 3/- per kg. The ripened mango is sold at the rate of Rs. 8-10/- kg for good quality variety. The highest quantity of mango collected in village Khajuri (56.92 Mg), which provides economic support in the summer month to the uphill villagers. Dry firewood is taken to the local market for sale. One head load of about 30-40 kg fetches a market value of Rs. 80/- to Rs. 120/- depending on the season. This forms a major share of the village economy on a sustainable basis. The highest quantity is collected in the village Majhihalma (259 Mg), which has easy access to the good forest. The consumption-to-sale ratio varies from 1:0.24 to 1:1.82. Patlamba and Rhodango have a 1:1.82 and 1:1.24, respectively, far more than in other villages where the consumption-to-sale ratio varies between 1:0.23 to 1:0.27. The villages closer to the deep forest area uphill, i.e., Khajuri, Rhodango, and Gortaoli go for siali leaf collection during the rainy season when the agriculture work is less intense. Gradually over the years, the availability of siali leaves has been reduced and the villagers must go far away to get a head load. The collected leaves are stitched to plates and air-dried in the shade during the rainy season. The leaf plates are bundled into 100 number packets for sale. The average weight of a packet varies from 350-400gm. Since the availability of siali leaves has been affected due to forest degradation, the forest around the habitations can be taken up for re-stocking, which will ameliorate the environment besides providing sustainable natural resources. This woody climber can cover the bare rocks where other vegetation can rarely establish. Earlier it was a good revenue source for the Government, while Tribal Development Co-operative Corporation (TDCC) would arrange marketing facilities. The Dongoria Kandha Development Agency (DKDA) can take up the work as it is its focus area. It will be a visible project within five years.

The tribal communities worship the mahua tree for its benefits from the fruit and flower due to its high glucose content, which is used in preparing different food items and is commonly consumed as country liquor. Here, the tree distribution is very much limited in the foothill area. Patlamba villagers go for collection in the uphill villages as few trees are available but in other village localities, the mahua tree is not available. To date, no attempt has been made for plantation on a large scale. It has the potential to provide a high level of sustainable income to tribal families or even elsewhere in the plains. The productivity of the tree varies greatly with age, i.e., crown spread. The Mahua flower is collected after clearing the base, i.e., dried leaves are removed or burnt. The beautifully scented flower attracts insects, honeybees, cattle, and the human population. The average flower production observed per plant is 10 to 20 kg, comparable to the available data, such as 16.5 kg and 21.5 kg sun-dried flowers in two years, 1968, 1969 for the Umerkote forest of Koraput (undivided)

district of Odisha. Prasad (1992) observed a yield range for 7 to 145 g tree⁻¹ flowers at SFRI Jabalpur. Dwivedi (1989) estimated the yield of mahua flowers from 10-140 kg tree⁻¹ year⁻¹ in 10-60-year-old trees. The lower flower yield may be attributed to the unhealthy growth of a tree. The plants are situated mostly on rocky hillocks and are widely scattered. Though authentic records of production are rare, the villager has the confidence to manage family expenses if 25-30 numbers of adult trees are available with a family.

The social tradition of the village community to worship the mahua tree gives sufficient protection from its cutting. People will never feel a mahua tree. A large-scale commercial plantation, with beneficiaries' involvement, will definitely provide sustainable income. The use of the Mahua flower in preparation of country liquor has been a common practice for a long. The country liquor, locally known as "mahuli," is used by most Tribals. The alcohol content of "mother liquor" is 4.4%, while that of spirit (distilled) is 19.58% (v/v) (Prasad 1992). The habit of the rural community of country liquor often leads to unsocial addiction and indebtedness to the businessman. The tamarind tree is also spread on hill slopes towards the top and protected by local inhabitants for its fruit. Fruit is collected in summer and the fruit coat is removed. It is preserved for the whole year in different pickles, etc. The area under study has a poor distribution of tamarind trees. It can be increased to a suitable number so that m of tamarind is collected and the processed tamarind pulp can be expo out. The commercial use of seed is also possible through the extraction of starch. In the forest area, sap from *Caryota* palm trees is collected for local use. It is commonly known as "salap." The villages having *Caryota* palm may collect the sap or lease it out to a village for the collection of sap. The collection time is thrice a day, i.e., early morning, midday, and evening, which starts in winter and continues through summer until the flow of sap stops. Local villages gather at a commonplace and consume the sap. The excess collection is sold to other villagers. The five-liter container costs Rs. 100 to Rs. 120 each. The collection of sap depends on the tree's age and the quantity of sap collection, which varies from 4-20 liters, which is well within the range (4.5 to 23 liters) reported for other areas (CSIR 1992). The *Caryota* sap is a very nutritious drink before it is fermented. It is rich in sugar and vitamins. Fresh sap contains sucrose up to 13.6% and a trace of reducing sugar, whereas fermented sap contains reduced sugar 1%, alcohol 3.0 to 4.5% and acetic acid 0.3% (CSIR 1992). After fermentation, it becomes alcohol. The fresh sap can also be used to prepare palm gur or jaggery, produced in other parts of India. In Kerala, jaggery is produced in villages and cooperative societies, as reported in the Wealth of India 1992 (CSIR 1992). Besides sap production, *Caryota* palm pith and stem wood produce sago and leaves for domestic purposes. The distribution of *Caryota* palm is in rocky places of a forest. The unmanaged collection of sap and cutting of leaves has led to the destruction of palms. This beautiful palm increases the scenic value of the forest on hill slopes. A policy is needed for artificial regeneration on a large scale by utilizing open forests so that commercial use for any

economic value will be possible. Sal is the dominant species of Eastern Ghats forests with an association like Bija, Sissoo, Asan, Dhaura, etc. The priority of the tribal community is sal. The seedling is used for a toothbrush, saplings are used for fencing and housing, poles of sal are cut for rural houses and the trees are cut for timber values. Hence sal is a target species of Tribals, though they traditionally worship the sal tree. The firewood and sal poles are cut regularly to meet the domestic need and cash income. This economic process is not economically acceptable. Gradually, the situation will change with the use of electricity and the LPG cooking process.

The growing forest can be used alternatively for any community benefit. The input-output ratio of MFP collection varies from 1:38.47 (Gortali) to 1:50.46 (Bhaliyabhata), much higher than the agriculture production sub-system. In the agriculture sub-system, the input-output ratio varies from 1:11.63 (Rhodango) to 1:23.32 (Bhalyabhata). The MFP collection is no investment practice for the low-income group, dominating the tribal pockets. The female workers and children mass mainly attend it. Hence in the guise of family sustenance, the education of boys and girls is neglected. The tribal community is intimately associated with both the agroecosystem and forest ecosystem. The valley cultivation is taken up on Nala (Stream) side with maize and paddy, which is prominent in foothill villages. Other cultivation practices, i.e., podu cultivation, mid-hill orchard and a home garden, are taken up in forest areas, the food base of uphill villages. Forest is also used for grazing animals.

Consumption pattern

Agriculture is the main food source for the villages. Per capita consumption of food items indicates inter-village variations in the use of cereals and legumes (Table 17). The quantity of use of cereals varies from 247.69 gm cap⁻¹ day⁻¹ (Khajuri) to 392.39 gm cap⁻¹ day⁻¹ (Rodanga) in uphill villages. The value is much higher in foothill villages, which varies from 213.25 gm cap⁻¹ day⁻¹ (Papikhunti) to 791.80 gm cap⁻¹ day⁻¹ (D. Kumbharbadi). The average per capita cereal consumption is higher in foothill villages and lower in uphill villages compared to the reported value of 525 gm cap⁻¹ day⁻¹ for tribal village Bhogibandha (Nayak et al. 1993) and the coastal village 585 gm cap⁻¹ day⁻¹ of Odisha (Sahoo 1993). Generally, the value is lower than that of the agricultural villages of Bhahinarayanpur (Nisanka and Misra 1990).

The highest per capita food consumption in village Khajuri (791.80 gm cap⁻¹ day⁻¹) is due to higher paddy cultivation in the valley and easy access to urban facilities near the market. The other village, Papikhunti, concentrates on vegetable production and there is no scope for paddy cultivation in the valley Nala (stream) sides. Access to the Public Distribution System (PDS) is better in these two villages than in other villages. Food consumption in all villages is less than the average requirement, as suggested by the national expert group of the ICMR (Gopalan et al. 1982). The highest value of Khajuri village is at par with the value reported for other villages in Odisha (Sahoo 1993) but higher than that reported for a tribal village on

the Mahendragiri foothills (Nayak et al. 1993). The uphill villages depend on the variety of minor millets produced in podu areas. In general, all villages suffer malnutrition due to insufficient food consumption. Illiteracy and addiction of tribal to low-cost liquor create health problems responsible for the economy's deterioration. The tribal community is associated with using country liquor in various rituals. Sometimes it spreads to full-time consumption of liquor, leaving the day-to-day family work. This is an adverse effect on society. The use of sap in *Caryota* has been recorded, but the per capita use could not be estimated as several users vary daily and the places of use are not fixed. But the collection quantity is accessed based on several trees and sample measurements.

The villagers use a traditional cooking system with "challah" where firewood (biomass) is used due to easy availability. Kerosene is used for lighting. Firewood collection by cutting immature trees is responsible for the deterioration of forest crops. The per capita per day consumption of firewood varies from 1.855 kg (Rodanga) to 3.080 kg (Khajuri) in uphill villages and 2.577 kg per day (Bhaliabhata) to 4.402 kg day⁻¹ (D. Kumbharbadi) in foothill villages. The average per day consumption is lower in uphill villages than in foothill villages. The annual per capita fuel wood consumption varies from 0.667 Mg (Rodanga) to 1.585 Mg (Khajuri), which is higher than the consumption rate reported for many Indian villages such as Haripur complex (0.642 t year⁻¹) of Odisha (Sahoo 1993), Sitting (0.59 t year⁻¹) Tamil Nadu (Dhenapal 1992), Bhgibandha 0.53 t yr⁻¹ tribal village (Nayak et al. 1993) and Bhabinara-Yampur (0.59 t yr⁻¹) an agricultural village of Odisha (Nisanka and Misra 1990), Uchangi (0.84 t yr⁻¹), Karnatak (Mishra et al. 1983). The average fuel wood consumption per household (family) reported in the study is well within the range reported for many villages. The value ranges from 8.626 kg family⁻¹ day⁻¹ (Rodanga) to 16.727 kg family⁻¹ day⁻¹ (D. Kumbharbadi). These values are similar to the value of Himalayan foothill villages (Moench 1989) but less than that of tribal villages in Odisha (Mohapatra 1992). Firewood is used as fuel energy for all villages and also meets the family income by selling firewood after collecting for a forest. This agrees with the data reported for many Indian villages (Gangwar and Ramakrishnan 1987). Easy access to firewood and subsistence village economy is responsible for 100% dependency on biomass energy. Mud stove cooking is the reason for the high consumption of firewood with far less heat utilization efficiency of 20.35% (Nisanka and Mishra 1989).

The sustainability of village ecosystem

The village ecosystem has three major sub-systems: agriculture, animal husbandry, and domestic. All these are interrelated among themselves and with the forest ecosystem. The relation can be described through the quantity of energy flow and its sustainability. The deficit of the village ecosystem is met by procuring materials from outside these systems. The agriculture sub-system production is insufficient to meet the villagers' food requirements. PDS rice is received (imported) to meet the gap.

Table 17. Per capita food consumption in the village ecosystem (g cap⁻¹ day⁻¹)

Items	Patlamba	Rodanga	Khajuri	Gortali
Rice	299.53	388.21	228.10	226.37
Maize	4.18	4.18	19.59	24.32
Finger millets (Mandia)	128.18	101.95	158.21	188.78
Pearl millets (Ghantia)	20.25	7.62	11.35	17.76
Common millets (Kangu)	77.64	29.97	14.98	27.16
Barnyard millets (Koshala)	118.81	106.23	77.41	91.22
Redgram legumes (Kandul)	26.61	10.93	13.51	25.77
Jhudanga	9.37	18.42	25.82	47.75
Kating	19.58	12.35	21.31	13.41
Vegetables	69.68	22.21	14.81	18.03
Turmeric	2.68	2.49	2.14	2.76
Ginger	1.67	1.19	1.34	1.80
Jack Fruit	17.57	11.45	5.97	17.69
Orange	-	0.90	0.36	0.21
Pineapple	33.63	5.68	67.31	51.41
Papaya	11.55	25.89	28.49	10.43
Dry food	6.19	5.44	1.26	1.11
Meat/others (fresh wt)	6.29	3.41	0.85	0.83
Dry fish (marine)	5.32	3.55	1.75	1.60
Sugar	0.50	0.50	0.36	0.48
Molasses	0.84	0.90	0.98	0.83

Table 17. Per capita food consumption in the village ecosystem (g cap⁻¹ day⁻¹) (Continued)

Items	Majhihalma	Bhaliabhatta	D. Kumbharbadi	Papikhunti
Rice	529.62	411.73	767.36	194.44
Maize	28.70	26.85	24.44	18.81
Finger millets (Mandia)	132.78	84.26	122.78	118.63
Barnyard millets (Koshala)	-	-	-	153.36
Redgram legumes (Kandul)	28.20	20.22	19.86	63.80
Jhudanga	21.30	22.38	21.81	-
Vegetables	26.76	29.78	39.31	51.65
Jack fruit	16.30	13.89	24.44	6.08
Papaya	6.48	9.26	25.00	14.47
Dry food	1.33	1.20	1.19	1.19
Meat/others (fresh wt)	1.11	1.20	0.92	1.07
Dry fish (marine)	2.11	2.04	1.75	1.71
Sugar	0.56	0.62	1.11	0.58
Molasses	0.65	0.77	0.69	0.58
Tobacco	0.74	0.31	1.67	0.58

The uphill villages sell a good quantity of minor millets and horticulture products (jackfruit, pineapple, banana, orange, mango) which can be recorded as high energy value. The forest ecosystem contributes more to the village's energy production in these village ecosystems. Thus, it is essential to make forests productive for sustainable productivity. An alternative source of firewood must be provided on a priority basis as the share of firewood in the village energy production was 60.61% average in the uphill village and 65.51% in foothill villages. Firewood consumption, whether for domestic use or sold outside, should be addressed immediately to reduce dependency on the forest. Regeneration of *S. robusta*, *Madhuca latifolia* and *T. indicus* and *Caryota* palm in and around forest lands may be encouraged as these trees are intimately connected to the livelihood and cultural practices of tribal communities. Planting short-rotation crops like bamboo, leafy vegetable of forest species and

tuber crops can meet village needs. The siali climber can cover exposed rocks besides providing siali leaves nearer to habitations. Suitable soil and moisture conservation measures are required to retain water (above ground and below ground) for a longer time on hill slopes, increasing the productivity of forest and agricultural crops. Agriculture production is important to provide food directly to the tribal community. Since the community is addicted to a set of crops, it is essential to enhance existing crop productivity. The share of agriculture production in the total village production was 27.07% in uphill villages and 26.12% in foothill villages. Training villagers for their traditional crop production and infrastructure development can strengthen the sustainability of agriculture production. Since the literacy rate is very low except in the village of D. Kumbharbadi, it is also suggested to improve literacy so that the population will accept technology input.

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