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## Role of coconut (*Cocos nucifera*) based agroforestry system in coastal Odisha

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**Abstract**

This paper presents a study carried out in Puri district of Odisha during June 2015 – May 2016 to determine the various role of coconut based agroforestry system in 15 different sizes (0.1 to 1.5 acre) of land holdings. The chosen coconut based agroforestry systems were visited in three cropping seasons such as kharif, rabi and summer and the observations on floral composition, number of common plant species, number of trees, various role of coconut based agroforestry system, contribution of coconut based agroforestry towards fuel and other wood requirement, yield of coconut based agroforestry systems were recorded. There are four different strata in which different perennial species were associated with coconut. The coconut based agroforestry systems of various sizes are playing important role for the household which include productive role, protective and ameliorative role, recreational and educational role as well as developmental role giving various kinds of tangible and intangible benefits starting from food, fodder, fuel etc. to biodiversity conservation with learning ground for children and adding many cultural and religious values. As the natural forest cover is less in coastal Odisha, substantial quantity of fuel wood was found to be derived from homegarden and the contribution of fuel wood production increased with increase of holding size up to 1.2acre. The coconut based agroforestry system of size 0.8 acre was found to be best among the holding sizes studied with regard to various functions.

**Keywords:** Coconut, agroforestry, fuelwood, yield, role, Odisha

**1. Introduction**

Coconut (*Cocos nucifera*) plays a significant role in the agrarian economy of India. Coconut is grown in more than 93 countries of the world in an area of 12.29 million ha with a total production in terms of copra equivalent of 11.04 million MT. Indonesia (25.63%), Philippines (23.91%) and India (19.20%) are the major coconut producing countries of the world. Coconut based agroforestry means agriculture along with woody component with coconut plant as a compulsory. In India the coconut based agroforestry are generally found in tropical and sub-tropical areas and characterized by high species diversity and usually three to four vertical canopy strata. These agroforestry systems consist of different layer of species starting from seasonal crops, perennial crops, woody components. The lower most being dominated by different vegetables like brinjal, greens, turmeric, ginger, mushroom, okra, chilli, tomato, cabbage, dioscorea, etc. and the second layer is comprising food plants such as banana, papaya, lemon, etc. The third layer is occupied by fruit trees like guava, drumstick, custard apple, etc. The upper layer is the tree layer which can be divided into two, consisting of the emergent full grown timber and fruit trees having height more than 20m and medium size trees of 10-20m. In the upper layer species like *Mangifera indica*, *Samanea saman*, *Bambusa vulgaris*, *B. tulda*, *Cocos nucifera*, *Areca catechu*, *Samanea saman*, *Artocarpus heterophyllus*, *Aegle mormalus*, *Tamarindus indica*, *Azadirachta indica*, *Leucaena leucocephala*, etc. are grown. In developing countries particularly in India coconut is either grown as mono-crop or as major component in the multiple cropping systems with or without livestock. In Odisha it occupies more than 60% of the perennial crop area and more than 30% of the total cropped area in coastal districts mostly Puri, Jagtsingpur, Balasore, Kendrapada and Khurda. Mostly due to water logged situation and favour in climatic condition add interest on coconut plantation. Apart from pure coconut plantation many farmers and the households are practicing different crop combination along with coconut. The coconut farming system is very promising as spacing is wide, the system affords higher incidence of light under the canopy and the limited effective root zone of the coconuts allows other crops within the grove. Especially in the coastal part of the district, vast lowland and homestead land areas are being planted with coconut. The advent of population pressure, less lands to cultivate and the worsening marginal conditions of farmlands prompt the need to go into farming systems that would optimize use of the limited land resource, thus intercropping, a form of agroforestry gained popularity among farmers.

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Basing on this background, an attempt was taken to assess the various role played by coconut based agroforestry system in coastal Odisha.

## 2. Materials and Methods

The present study was carried out in the Puri district of Odisha, a coastal district along the Bay of Bengal during June 2015 - May 2016. The experiment was laid out in Randomised Block Design (RBD) with three replications. For this the district was divided into three regions, each region represented one replication. The region-I covered the eastern part of the Puri district comprising four blocks such as Gop, Kaktpur, Astaranga and Puri. The region-II covered North central part of the district comprising Pipili, Delanga, Satyabadi and Kanasa blocks. The region-III covered the western part of the district comprising Chilika, Krushnaprasad and Brahmagiri blocks. In each region, the role of coconut based agroforestry of 15 different sizes were studied. The observations were recorded on floral composition, number of common plant species, number of trees, various role of coconut based agroforestry system, yield and contribution of coconut based agroforestry towards fuel and other wood requirement in coconut based agroforestry system.

## 3. Results and Discussion

### i. Common perennial species in different strata of coconut based agroforestry system

The common perennial plants were observed in four different strata under the coconut based agroforestry systems studied in fifteen different land holding sizes in Puri district of Odisha. The strata are more than 15m, 10-15m, 5-10m and less than 5m. In all holding size coconut occupied the top most storey (>15m). Between the holding size of T<sub>3</sub> and T<sub>10</sub> the common tree species associated in these strata were siris, rain trees, eucalyptus and karanj. No perennial plant was found with coconut in the holding size of 1.1acre and above. In very small holding size like T<sub>1</sub> and T<sub>2</sub> the presence of other trees were zero or negligible because of not availability of space. In relatively higher holding size (T<sub>12</sub> to T<sub>15</sub>) no other trees were associated because in such holdings sizes paddy is grown which needs more access to light. The common perennial plants were arecanut, mango and bamboo up to 1.2acre size holding in the strata of 10-15m height. In relatively higher size holding within this limit (T<sub>3</sub> to T<sub>12</sub>) additional species like acacia, teak and jackfruit are grown. No perennial trees are found in the holding size T<sub>13</sub> to T<sub>15</sub> other than coconut in these strata. People grow these perennial trees along with coconut depending upon holding size to meet various requirements like food, fodder, fuel, timber etc. in addition to get a congenial microclimate and generate additional money and employment on the same land holding. In the strata 5-10m height mostly crops were in different holding sizes of coconut based agroforestry system. Drumstick, papaya and

guava are found commonly in small size holding like T<sub>1</sub> and T<sub>2</sub>. In relation to higher holdings size like T<sub>3</sub> to T<sub>12</sub> the common perennial plants were guava, papaya, pomegranate, drumstick and bael. People have grown these plants in different sizes of holding primarily to supplement the food from these plants. The wider spacing of coconut favors growing these fruit plants under it. In the strata of less than 5m height the common plants are citrus, banana and curry leaf from T<sub>1</sub> to T<sub>12</sub> holding size. People are deliberately kept these plants to get food and leaf from these plants which are frequently required in household of rural people. In holding size 1.3acre to 1.5acre no associated perennial plants were found associated with coconut in any strata. This is because the higher size holding are mostly used for coconut paddy cropping system in the district. Different plants have occupied in different strata may be due their growth rate, light requirement and deliberate arrangement by the grower to intensify the coconut based land use system and explore maximum benefit. Similar study have been reported by Rahaman *et al.*, (2013) [13], Nair, (2008) [12] and Fernades *et al.*, (1984) [5].

### ii. Number of perennial plant in coconut based agroforestry

The number of common perennial plant species including coconut, timber species and fruit species other than coconut varied remarkably in the coconut based agroforestry system of Puri district (Table 1). The number of coconut trees per holding varied from 25 to 118 with an increasing number towards higher size units. The number of coconut trees increased with increase of size of unit because of availability of more space to accommodate the trees on the other hand the number of coconut trees on acre basis ranged from 79 to 230 with a decreasing trend towards higher size plot. This indicates that the density of coconut trees is significantly higher in smaller size unit than the larger size unit. However the values beyond 0.8acre were statistically at par with each other. This signifies that towards higher holding sizes the spacing of coconut trees maintained is more or less same. The number of timber species varied from 0 to 6 per holding. In holding size of 1.3acre to 1.5acre less number of timber species was found to be grown with coconut. This means towards higher holding sizes people prefer less mixture of perennial plants. In terms of number of timber species per acre basis significantly higher number of plants was found in relatively smaller size of plot. On others the number of timber species in coconut based agroforestry system decreased with increase of holding size. It varied from 0 to 27 numbers per acre. This reflects that the smaller size plots are comparatively denser because of more number of trees per unit area than the higher size plots. In higher size plot like T<sub>13</sub>, T<sub>14</sub> and T<sub>15</sub> no other trees are present.

**Table 1:** Number of common perennial plant species in coconut based agroforestry system in Puri district of Odisha

Treatment (Holding size)	Coconut tree		Timber species		Fruit species other than coconut	
	Per holding	Per acre	Per holding	Per acre	Per holding	Per acre
T <sub>1</sub> (0.1 acre)	25	230	3	27	3	33
T <sub>2</sub> (0.2 acre)	38	188	3	15	4	20
T <sub>3</sub> (0.3 acre)	50	166	4	12	4	12
T <sub>4</sub> (0.4 acre)	59	147	5	12	4	10
T <sub>5</sub> (0.5 acre)	63	126	5	9	5	10
T <sub>6</sub> (0.6 acre)	65	109	5	8	5	8
T <sub>7</sub> (0.7 acre)	66	95	6	8	5	7
T <sub>8</sub> (0.8 acre)	66	82	6	8	7	9

T <sub>9</sub> (0.9 acre)	68	76	4	4	3	3
T <sub>10</sub> (1.0 acre)	72	72	4	4	3	3
T <sub>11</sub> (1.1 acre)	85	77	3	2	2	2
T <sub>12</sub> (1.2 acre)	92	77	3	2	0	0
T <sub>13</sub> (1.3 acre)	100	77	0	0	0	0
T <sub>14</sub> (1.4 acre)	110	78	0	0	0	0
T <sub>15</sub> (1.5 acre)	118	79	0	0	0	0
SE <sub>m(±)</sub>	1.68	4.66	0.31	1.26	0.22	1.17
CD <sub>(0.05)</sub>	4.89	13.51	0.92	3.67	0.65	3.38

The number of fruit species other than coconut also found differently per holding in different size of unit. 2 to 7 number of fruit species were found per holding from 0.1acre to 1.1acre and no fruit trees were found under coconut based agroforestry system. With regards to number of fruit species per acre the number was significantly higher in smaller size holding than the larger size holding. It ranged from 0 to 33. Like coconut trees and timber species the fruit species were found more per unit area in comparatively small size plot. This shows that people tried to accommodate different type of trees which are essential to met different kinds of produces in their plot even if the size at the plot is small. The results are in line with findings of Jhon and Nair, (2002) [8], Ahmed and Rahaman, (2004) [2] and Ahmad *et al.*, (2004) [3].

### iii. Role played by coconut based agroforestry system

The agro climatic condition of Puri district of Odisha is very suitable for growing coconut. In addition to this presence of more Hindu communities and large number of religious institution coconut finds a very sacred place in this part of Odisha since long time. Coconut based agroforestry system are playing multiple roles like various productive, protection and ameliorative, recreational and educational as well as developmental role. The common productive role is supply of various kinds of products like food, fodder, fuel, oil, shading material, broom material, timber etc. The common protective and ameliorative role includes acting as CO<sub>2</sub> sink, restoring soil productivity, provides shade, moderating temperature, reducing wind speed, creating congenial micro climate, providing habitat for birds, acting as germplasm bank and helping in biodiversity conservation. It provides various recreational and educational roles such as aesthetic value,

acting as learning ground for children and providing cultural and religious value. It also helps in generating employment in small holdings and employment as well as cash in large holdings. Many researchers also have highlighted such roles of homestead agroforestry systems. (Rahman *et al.* (2013) [13], Nair (2008) [12], Ahmed *et al.* (2004) [3], Senaid *et al.* (2004) [14], Arunachalam *et al.* (2007) [4] and Mohapatra *et al.* (2007) [10]. However in comparatively large holding which are more than 1.2acre where species diversity is less the role of the system is also comparatively less.

### iv. Yield of different components of coconut based agroforestry system

The yield of various components under the coconut based agroforestry system varied remarkably among different holding sizes (Table 2). The number of coconuts per annum varied from 565 to 5300, the number of coconut increases progressively with increase of holding size. This is due to more number of trees in higher holding. The yield of fruit other than coconut varied significantly among the holding sizes it increase from 27 kg (T<sub>1</sub>) per annum to 181 kg (T<sub>8</sub>) per annum. With increase of holding size. This may be attributed to presence of more fruit bearing trees in higher holding. However beyond T<sub>8</sub> the yield of fruit other than coconut decreases with increase of holding size. This may be described reduction of fruit trees in higher holding sizes. The yield of seasonal crops comprising kharif, rabi and summer crop varied from 85kg to 1970kg per annum. The yield increase with increase of holding size. This is obviously because of more space available towards higher holding for cultivation of seasonal crops.

**Table 2:** Yield of different components of coconut based agroforestry system in Puri district of Odisha

Treatment (Holding size)	Number of Coconut per annum	Yield of fruits other than coconut (kg/annum)	Yield of seasonal Crops(kg/annum)
T <sub>1</sub> (0.1 acre)	565	27	85
T <sub>2</sub> (0.2 acre)	933	49	137
T <sub>3</sub> (0.3 acre)	1123	73	260
T <sub>4</sub> (0.4 acre)	1270	94	440
T <sub>5</sub> (0.5 acre)	1486	126	527
T <sub>6</sub> (0.6 acre)	1657	163	660
T <sub>7</sub> (0.7 acre)	1765	172	763
T <sub>8</sub> (0.8 acre)	1953	181	820
T <sub>9</sub> (0.9 acre)	2137	122	940
T <sub>10</sub> (1.0 acre)	2347	98	1221
T <sub>11</sub> (1.1 acre)	2580	64	1503
T <sub>12</sub> (1.2 acre)	2740	62	1620
T <sub>13</sub> (1.3 acre)	4300	53	1787
T <sub>14</sub> (1.4 acre)	4533	43	1910
T <sub>15</sub> (1.5 acre)	5300	33	1970
SE <sub>m(±)</sub>	95	4	12
CD <sub>(0.05)</sub>	274	11	33

### v. Contribution of coconut based agroforestry system towards fuel and other wood requirement

The Puri district of Odisha is away from the natural forest. People in rural areas mostly depend on homesteads to meet their wood requirement. Therefore coconut based agroforestry system plays an important role in contribution the fuel and other wood requirement (Table 3). It was observed that contribution of different holding sizes of coconut based agroforestry system varied from 7.6% to 49.2% of the total consumption of house. The contribution went on increasing from 0.1acre size to 1.2acre size. This may be due to availability of more wood from coconut and other perennial species. Beyond 1.2acre the contribution was 37.4% to 44.8% because here may the wood was obtained from coconut trees. Getting of energy from homestead has also been reported by some researcher like Ahmed *et al.*, (2004) [3], Mohiuddin *et al.*, (1999) [11], Millat *et al.*, (1994) [9], Ahmed and Rahman (2004) [2], Rahman *et al.*, (2013) [13] and Ahmed and Hazarika (2007) [1].

**Table 3:** Contribution of coconut based agroforestry towards fuel and other wood requirement

Treatments (Holding size)	Contribution (%) of total consumption in house
T <sub>1</sub> (0.1 acre)	7.6
T <sub>2</sub> (0.2 acre)	10.7
T <sub>3</sub> (0.3 acre)	14.8
T <sub>4</sub> (0.4 acre)	18.4
T <sub>5</sub> (0.5 acre)	22.9
T <sub>6</sub> (0.6 acre)	26.5
T <sub>7</sub> (0.7 acre)	31.4
T <sub>8</sub> (0.8 acre)	34.8
T <sub>9</sub> (0.9 acre)	37.8
T <sub>10</sub> (1.0 acre)	43.5
T <sub>11</sub> (1.1 acre)	47.8
T <sub>12</sub> (1.2 acre)	49.2
T <sub>13</sub> (1.3 acre)	37.4
T <sub>14</sub> (1.4 acre)	40.5
T <sub>15</sub> (1.5 acre)	44.8
SEm(±)	0.6
CD(0.05)	1.8

### 4. Conclusion

The coconut based agroforestry system of Puri district of Odisha was observed to be rich in structure and various function upto holding size of 1.2acre. The treatments upto 1.2acre size were found to be well composed of different types of plants such as tree species, fruit plants and seasonal crops along with coconut in four different layers. Coconut based agroforestry systems particularly upto 1.2acre size are providing not only financial benefits but various types of tangible and intangible benefits also to the households including food, fuel, timber, fodder, thatching and broom material, shade, good microclimate, habitat for birds, learning ground for children, aesthetic, cultural and religious values. The contribution of coconut based system towards fuel production was also found significant. Out of the 15 treatments, the coconut based agroforestry system of size 0.8 acre was found to be best among the holding sizes studied with regard to various functional role.

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