



Coconut (*Cocos nucifera*)-based farming system: a viable land use option for small and marginal farmers in coastal Odisha

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ABSTRACT

An investigation was carried out during 2012–2013 in Puri district of Odisha to study the composition, structure and role of coconut (*Cocos nucifera* L.) based farming in 15 different holding sizes, i.e. 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4 and 1.5 acre. The experiment was laid out in randomised block design with three replications. The smaller holdings were found close to houses as homegardens and comparatively larger holdings were found little away from the houses. The composition was found very diverse consisting of perennial trees, annual crops and seasonal crops. 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. As the natural forest cover is less in coastal Odisha, a 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 1.2 acre. The net return varied from ₹ 5 617 to ₹ 32 850/annum showing the income level increased with increase in holding size, while the economics was calculated on acre basis, the net income ranged from ₹ 56 167 to ₹ 21 900 indicating decreasing trend towards higher holding sizes. In terms of market orientation, the smaller unit sizes were found more subsistence and less commercial than bigger holding sizes and vice versa. The coconut based agroforestry system of size 0.8 acre (perennials-coconut, siris, rain tree, eucalyptus, acacia, areca nut, mango, sissoo, teak, jackfruit, bamboo, guava, pomegranate, papaya, drumstick, bael, citrus, banana, curry leaf; seasonals-pine apple, yam, arrowroot, turmeric, ginger, brinjal, okra, bitter gourd, ridge gourd, chilli, greens, cowpea, tomato, cauliflower, pumpkin; mushroom-paddy straw/oyster; fish- rohu, silver carp, grass carp; cattle, buffalo, goat, poultry, duck) was found to be the best among the holding sizes studied with regard to viability of landuse.

Key words: Agroforestry, Coconut, Farming systems, Homegarden, Odisha

Coconut (*Cocos nucifera* L.) plays a significant role in the agrarian economy of India particularly in coastal areas. Apart from the importance of copra and coconut oil which is widely used in the manufacture of soaps, hair oil, cosmetics and other industrial products, the husk is a source of fibre which supports a sizeable coir industry. The tender nut supplies coconut water, a popular thirst quencher of health and hygienic value. The traditional areas of coconut in India are the states of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Odisha, Goa, West Bengal, Pondicherry, Maharashtra and Islands of Lakshadweep and Andaman and Nicobar (Anon. 2009). Coconut is grown in 1.94 million ha in 19 states and 3 Union Territories of the country

producing 15730 million nuts with an average productivity of 8303 nuts per ha or 44.27 nuts/palm/year. It occupies more than 60% of the perennial crop area and more than 30% of the total cropped area in coastal districts of Odisha mostly Puri, Jagtsingpur, Balasore, Kendrapada and Khurda.

In India, the coconut based agroforestry systems are generally found in tropical and sub-tropical areas and are characterized by high species diversity and usually with three to four vertical canopy strata. Coconut-based farming system is a common practice in the coastal districts of Odisha. The advent of population pressure, less lands to cultivate and the worsening marginal conditions of farmlands has prompted the need to go into intensification of farming systems in the form of agroforestry. Here the viability of this system was studied under different holding sizes in coastal Odisha to assess the relative efficacy.

MATERIALS AND METHODS

The investigation was carried out in Puri district of Odisha, India which is located at 19° 28' to 26° 35' N latitude, and 84° 29' to 86° 25' E longitude along the Bay of

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Bengal. The study area normally receives rainfall of about 1 712 mm per annum. The experiment was laid out in randomised block design with three replications. For this the district was divided into three regions, each region representing 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. The treatments were coconut based agroforestry system under fifteen different holding sizes such as 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4 and 1.5 acre. From each replication 30 sample plots (2 for each treatment) were selected whose data were finally pooled into 15 sets (one for each treatment). The required observations were recorded in *kharif*, *rabi* and summer seasons.

The observations were recorded on floral composition, height of plants, size of fish pond, number of mushroom beds, number livestock animals, crops taken in different seasons, role played by coconut-based agroforestry/farming system, contribution of coconut based agroforestry towards wood production and economics of coconut-based farming systems. The height of plants was measured by Ravi altimeter following standard procedure. The statistical analyses of the data were carried out using analysis of variance (ANOVA) technique for a randomised block design as per the standard

methods described by Gomez and Gomez (1985) using MSTAT-C (Version 1.41, Crop and Soil Department, Michigan State University). The results are presented at 5% level of significance ($P=0.05$).

RESULTS AND DISCUSSION

The various aspects of coconut-based agroforestry/farming systems studied which have proved these as viable landuse system in coastal Odisha are presented here.

Common perennial species in coconut-based farming system

The coconut-based agroforestry systems studied in fifteen different land holding sizes witnessed broadly four different strata in which different perennial species were associated with coconut. The strata were more than 15m, 10-15m, 5-10m and less than 5m. In all holding sizes coconut occupied the top most storey (>15m). Between the holding size of T_3 and T_{10} the common tree species associated in these strata were siris, rain tree, eucalyptus and karanj. In the holding size of 1.1 acre and above no perennial plant was found with coconut. In very small holding size like T_1 and T_2 , the presence of other trees were zero or negligible because of non-availability of space. In relatively higher size holding (T_{12} to T_{15}) no other trees were associated because in such holding sizes paddy is grown (Table 1), which needs more access to light. In the strata of 10-15m height the common perennial plants were

Table 1 Common perennial species in multi-storied coconut-based farming system in Puri district of Odisha

| Treatment (holding size) | Species in different height classes | | | |
|-----------------------------|--|--|--|--|
| | >15m | 10-15m | 5-10m | <5m |
| T_1 (0.1 acre) | Coconut (<i>Cocos nucifera</i>) | Arecanut (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Bamboo (<i>Bambusa vulgaris</i>) | Drumstick (<i>Moringa olifera</i>), Papaya (<i>Carica papaya</i>), Guava (<i>Psidium guajava</i>), Gambhar (<i>Gmelina arborea</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |
| T_2 (0.2 acre) | Coconut (<i>Cocos nucifera</i>), Siris (<i>Albizia lebbek</i>) | Arecanut (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | Guava (<i>Psidium guajava</i>), Papaya (<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |
| T_3 (0.3 acre) | Coconut (<i>Cocos nucifera</i>), Siris (<i>Albizia lebbek</i>), Rain tree (<i>Samanea saman</i>), Eucalyptus (Eucalyptus hybrid), Karanj (<i>Pongamia pinnata</i>) | Acacia (<i>Acacia auriculiformis</i>), Arecanut tree (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Sissoo (<i>Dalbergia sissoo</i>), Teak (<i>Tectona grandis</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | Guava (<i>Psidium guajava</i>), Pomogranate (<i>Punica granatum</i>), Papaya (<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |
| T_4 (0.4 acre) | Coconut (<i>Cocos nucifera</i>), Siris (<i>Albizia lebbek</i>), Rain tree (<i>Samanea saman</i>), Eucalyptus (Eucalyptus hybrid), Karanj (<i>Pongamia pinnata</i>) | Acacia (<i>Acacia auriculiformis</i>), Arecanut tree (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Sissoo (<i>Dalbergia sissoo</i>), Teak (<i>Tectona grandis</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | Guava (<i>Psidium guajava</i>), Pomogranate (<i>Punica granatum</i>), Papaya (<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |

Contd.

Table 1 (Continued)

| Treatment (holding size) | Species in different height classes | | | |
|-----------------------------|--|---|---|--|
| | >15m | 10-15m | 5-10m | <5m |
| T ₅ (0.5 acre) | Coconut (<i>Cocos nucifera</i>), Siris (<i>Albizia lebbek</i>), Rain tree (<i>Samanea saman</i>), Eucalyptus (Eucalyptus hybrid), Karanj (<i>Pongamia pinnata</i>) | Acacia (<i>Acacia auriculiformis</i>), Arecanut (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Sissoo (<i>Dalbergia sissoo</i>), Teak (<i>Tectona grandis</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | Guava (<i>Psidium guajava</i>), Pomogranate (<i>Punica granatum</i>), Papaya (<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |
| T ₆ (0.6 acre) | Coconut (<i>Cocos nucifera</i>), Siris (<i>Albizia lebbek</i>), Rain tree (<i>Samanea saman</i>), Eucalyptus (Eucalyptus hybrid), Karanj (<i>Pongamia pinnata</i>) | Acacia (<i>Acacia auriculiformis</i>), Arecanut (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Sissoo (<i>Dalbergia sissoo</i>), Teak (<i>Tectona grandis</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | Guava (<i>Psidium guajava</i>), Pomogranate (<i>Punica granatum</i>), Papaya (<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |
| T ₇ (0.7 acre) | Coconut (<i>Cocos nucifera</i>), Siris (<i>Albizia lebbek</i>), Rain tree (<i>Samanea saman</i>), Eucalyptus (Eucalyptus hybrid), Karanj (<i>Pongamia pinnata</i>) | Acacia (<i>Acacia auriculiformis</i>), Arecanut (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Sissoo (<i>Dalbergia sissoo</i>), Teak (<i>Tectona grandis</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | Guava (<i>Psidium guajava</i>), Pomogranate (<i>Punica granatum</i>), Papaya (<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |
| T ₈ (0.8 acre) | Coconut (<i>Cocos nucifera</i>), Siris (<i>Albizia lebbek</i>), Rain tree (<i>Samanea saman</i>), Eucalyptus (Eucalyptus hybrid), Karanj (<i>Pongamia pinnata</i>) | Acacia (<i>Acacia auriculiformis</i>), Arecanut (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Sissoo (<i>Dalbergia sissoo</i>), Teak (<i>Tectona grandis</i>), Kadam (<i>Anthocephalus cadamba</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | Guava (<i>Psidium guajava</i>), Pomogranate (<i>Punica granatum</i>), Papaya (<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |
| T ₉ (0.9 acre) | Coconut (<i>Cocos nucifera</i>), Siris (<i>Albizia lebbek</i>), Rain tree (<i>Samanea saman</i>), Eucalyptus (Eucalyptus hybrid), Karanj (<i>Pongamia pinnata</i>) | Acacia (<i>Acacia auriculiformis</i>), Arecanut (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Sissoo (<i>Dalbergia sissoo</i>), Teak (<i>Tectona grandis</i>), Kadam (<i>Anthocephalus cadamba</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | Guava (<i>Psidium guajava</i>), Pomogranate (<i>Punica granatum</i>), Papaya (<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |
| T ₁₀ (1.0 acre) | Coconut (<i>Cocos nucifera</i>), Siris (<i>Albizia lebbek</i>), Rain tree (<i>Samanea saman</i>), Eucalyptus (Eucalyptus hybrid), Karanj (<i>Pongamia pinnata</i>) | Acacia (<i>Acacia auriculiformis</i>), Arecanut (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Sissoo (<i>Dalbergia sissoo</i>), Teak (<i>Tectona grandis</i>), Kadam (<i>Anthocephalus cadamba</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | Guava (<i>Psidium guajava</i>), Pomogranate (<i>Punica granatum</i>), Papaya (<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |
| T ₁₁ (1.1 acre) | Coconut (<i>Cocos nucifera</i>) | Acacia (<i>Acacia auriculiformis</i>), Arecanut | Guava (<i>Psidium guajava</i>), Pomogranate (<i>Punica</i> | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry |

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Table 1 (Concluded)

| Treatment (holding size) >15m | Species in different height classes | | |
|--|--|--|--|
| | 10-15m | 5-10m | <5m |
| | (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Sissoo (<i>Dalbergia sissoo</i>), Teak (<i>Tectona grandis</i>), Kadam (<i>Anthocephalus cadamba</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | <i>granatum</i>), Papaya(<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | leaf (<i>Murraya koenigii</i>) |
| T ₁₂ (1.2 acre) Coconut (<i>Cocos nucifera</i>) | Acacia (<i>Acacia auriculiformis</i>), Arecanut (<i>Areca catechu</i>), Mango (<i>Mangifera indica</i>), Sissoo (<i>Dalbergia sissoo</i>), Teak (<i>Tectona grandis</i>), Kadam (<i>Anthocephalus cadamba</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Bamboo (<i>Bambusa vulgaris</i>) | Guava (<i>Psidium guajava</i>), Pomogranate (<i>Punica granatum</i>), Papaya (<i>Carica papaya</i>), Drumstick (<i>Moringa olifera</i>), Bael (<i>Aegle marmelos</i>) | Citrus (<i>Citrus spp</i>), Banana (<i>Musa paradisiaca</i>), Curry leaf (<i>Murraya koenigii</i>) |
| T ₁₃ (1.3 acre) Coconut (<i>Cocos nucifera</i>) | | | |
| T ₁₄ (1.4 acre) Coconut (<i>Cocos nucifera</i>) | | | |
| T ₁₅ (1.5 acre) Coconut (<i>Cocos nucifera</i>) | | | |

arecanut, mango and bamboo up to 1.2 acre size holding. No perennial trees were found in the holding size T₁₃ to T₁₅ 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 5-10 m height mostly food plants are grown in different holding sizes of coconut based agroforestry system. In small size holding like T₁ and T₂ drumstick, papaya and guava are found commonly. In relation to higher holdings size like T₃ to T₁₂ 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 favours growing these fruit plants under it. In the strata of less than 5 m height the common plants are citrus, banana and curry leaf from T₁ to T₁₂ holding size. People have deliberately kept these plants to get food and leaf from these plants which are frequently required in household of rural people. In holding size 1.3 acre to 1.5 acre no associated perennial plants were found with coconut in any strata. This is because the higher size holdings are mostly used for coconut-paddy cropping system in the district. Different plants have occupied in different strata may be due to their growth rate, light requirement and deliberate arrangement by the grower to intensify the coconut based land use system and explore maximum benefit. Similar studies have been reported by Rahaman *et al.* (2013) and Nair (2008).

Common annual and seasonal crops in coconut-based farming system

A number of common annual and seasonal crops were found to be grown in coconut based farming system in Puri district of Odisha (Table 2). In very small size holdings like 0.1 acre and 0.2 acre common annual crops were yam and turmeric. In holding size of 0.3 acre to 1.2 acre the common annual crops were yam, arrowroot, turmeric, colocasia and pineapple.

More numbers of annual crops are grown in relatively higher size holdings because of more availability of space as well as light on the ground. These annual crops are generally suitable to be grown under partial shade of tree canopy. Manjunath *et al.* (1998), Isaac and Nair (2008) and Maheswarappa *et al.* (2000) have reported similar findings. However, in comparatively large plots like 1.3 acre and more, no annual crops were found other than paddy. With regards to common seasonal crops, all holding sizes possessed crops in all the three seasons such as *kharif*, *rabi* and summer along with coconut trees. In *kharif*, the common intercrops were brinjal, okra, bitter gourd, chilli and greens in holding size of 0.1 acre to 1.2 acre with additional crop of cowpea in relatively higher size plot. Beyond 1.2 acre, paddy was mostly grown in *kharif* with coconut. In *rabi* the common crops grown were tomato, brinjal and beans up to 0.3 acre size where as additional crops like cauliflower, onion and greens were found in relatively higher size holding up to 1.2 acre. Beyond 1.2 acre, no *rabi* crops were grown under coconut. In summer, the common crops were brinjal, chilli, beans up to 0.3 acre and additional crop of pumpkin in higher size

Table 2 Common annual and seasonal crops in coconut-based farming system in Puri district of Odisha

| Treatment (holding size) | Common annual crops | Common seasonal crops | | |
|-----------------------------|--|---|---|---|
| | | <i>Kharif</i> | <i>Rabi</i> | Summer |
| T ₁ (0.1 acre) | Yam (<i>Dioscorea alata</i>), Turmeric (<i>Curcuma longa</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Bean (<i>Phaseolus vulgaris</i>) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp) |
| T ₂ (0.2 acre) | Yam (<i>Dioscorea alata</i>), Turmeric (<i>Curcuma longa</i>), Arrowroot (<i>Curcuma angustifolia</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Bean (<i>Phaseolus vulgaris</i>) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp) |
| T ₃ (0.3 acre) | Pine apple (<i>Anonas comosus</i>), Yam (<i>Dioscorea alata</i>), Arrowroot (<i>Curcuma angustifolia</i>), Turmeric (<i>Curcuma longa</i>), Colocasia (<i>Colocasia esculenta</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Bean (<i>Phaseolus vulgaris</i>) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp) |
| T ₄ (0.4 acre) | Pine apple (<i>Anonas comosus</i>), Yam (<i>Dioscorea alata</i>), Arrowroot (<i>Curcuma angustifolia</i>), Turmeric (<i>Curcuma longa</i>), Colocasia (<i>Colocasia esculenta</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Ridge gourd, Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp), Cow pea (<i>Vigna unguiculata</i>) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Cauliflower (<i>Brassica oleracea</i> var. <i>botrytis</i>), Onion (<i>Allium cepa</i>), Greens (<i>Amaranthus</i> spp) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Pumpkin (<i>Cucurbita maxima</i>), Greens (<i>Amaranthus</i> spp) |
| T ₅ (0.5 acre) | Pine apple (<i>Anonas comosus</i>), Yam (<i>Dioscorea alata</i>), Arrowroot (<i>Curcuma angustifolia</i>), Turmeric (<i>Curcuma longa</i>), Ginger (<i>Zingiber officinale</i>), Colocasia (<i>Colocasia esculenta</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Ridge gourd, Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp), Cowpea (<i>Vigna unguiculata</i>) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Cauliflower (<i>Brassica oleracea</i> var. <i>botrytis</i>), Onion (<i>Allium cepa</i>), Greens (<i>Amaranthus</i> spp) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Pumpkin (<i>Cucurbita maxima</i>), Greens (<i>Amaranthus</i> spp) |
| T ₆ (0.6 acre) | Pine apple (<i>Anonas comosus</i>), Yam (<i>Dioscorea alata</i>), Arrowroot (<i>Curcuma angustifolia</i>), Turmeric (<i>Curcuma longa</i>), Ginger (<i>Zingiber officinale</i>), Colocasia (<i>Colocasia esculenta</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Ridge gourd, Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp), Cowpea (<i>Vigna unguiculata</i>) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Cauliflower (<i>Brassica oleracea</i> var. <i>botrytis</i>), Onion (<i>Allium cepa</i>), Greens (<i>Amaranthus</i> spp) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Pumpkin (<i>Cucurbita maxima</i>), Greens (<i>Amaranthus</i> spp) |
| T ₇ (0.7 acre) | Pine apple (<i>Anonas comosus</i>), Yam (<i>Dioscorea alata</i>), Arrowroot (<i>Curcuma angustifolia</i>), Turmeric (<i>Curcuma longa</i>), Ginger (<i>Zingiber officinale</i>), Colocasia (<i>Colocasia esculenta</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Ridge gourd, Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp), Cowpea (<i>Vigna unguiculata</i>) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Cabbage (<i>Brassica oleracea</i> var. <i>capitata</i>), Cauliflower (<i>Brassica oleracea</i> var. <i>botrytis</i>), Onion (<i>Allium cepa</i>), Greens (<i>Amaranthus</i> spp) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Pumpkin (<i>Cucurbita maxima</i>), Greens (<i>Amaranthus</i> spp) |
| T ₈ (0.8 acre) | Pine apple (<i>Anonas comosus</i>), Yam (<i>Dioscorea alata</i>), Arrowroot | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), |

Contd.

Table 2 (Concluded)

| Treatment (holding size) | Common seasonal crops | | | |
|-----------------------------|--|---|---|---|
| | Common annual crops | Kharif | Rabi | Summer |
| | (<i>Curcuma angustifolia</i>), Turmeric (<i>Curcuma longa</i>), Ginger (<i>Zingiber officinale</i>), Colocasia (<i>Colocasia esculenta</i>) | (<i>Momordica charantia</i>), Ridge gourd, Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp), Cowpea (<i>Vigna unguiculata</i>) | Cauliflower (<i>Brassica oleracea</i> var. <i>botrytis</i>), Greens (<i>Amaranthus</i> spp) | Pumpkin (<i>Cucurbita maxima</i>), Greens (<i>Amaranthus</i> spp) |
| T ₉ (0.9 acre) | Pine apple (<i>Ananas comosus</i>), Yam (<i>Dioscorea alata</i>), Arrowroot (<i>Curcuma angustifolia</i>), Turmeric (<i>Curcuma longa</i>), Ginger (<i>Zingiber officinale</i>), Colocasia (<i>Colocasia esculenta</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Ridge gourd, Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp), Cowpea (<i>Vigna unguiculata</i>) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Cauliflower (<i>Brassica oleracea</i> var. <i>botrytis</i>), Greens (<i>Amaranthus</i> spp) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Pumpkin (<i>Cucurbita maxima</i>), Greens (<i>Amaranthus</i> spp) |
| T ₁₀ (1.0 acre) | Pine apple (<i>Ananas comosus</i>), Yam (<i>Dioscorea alata</i>), Arrowroot (<i>Curcuma angustifolia</i>), Turmeric (<i>Curcuma longa</i>), Ginger (<i>Zingiber officinale</i>), Colocasia (<i>Colocasia esculenta</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Ridge gourd, Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp), Cowpea (<i>Vigna unguiculata</i>) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Cauliflower (<i>Brassica oleracea</i> var. <i>botrytis</i>), Greens (<i>Amaranthus</i> spp) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Pumpkin (<i>Cucurbita maxima</i>), Greens (<i>Amaranthus</i> spp) |
| T ₁₁ (1.1 acre) | Pine apple (<i>Ananas comosus</i>), Yam (<i>Dioscorea alata</i>), Arrowroot (<i>Curcuma angustifolia</i>), Turmeric (<i>Curcuma longa</i>), Ginger (<i>Zingiber officinale</i>), Colocasia (<i>Colocasia esculenta</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Ridge gourd, Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp), Cowpea (<i>Vigna unguiculata</i>) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Cauliflower (<i>Brassica oleracea</i> var. <i>botrytis</i>), Greens (<i>Amaranthus</i> spp) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Pumpkin (<i>Cucurbita maxima</i>), Greens (<i>Amaranthus</i> spp) |
| T ₁₂ (1.2 acre) | Pine apple (<i>Ananas comosus</i>), Yam (<i>Dioscorea alata</i>), Arrowroot (<i>Curcuma angustifolia</i>), Turmeric (<i>Curcuma longa</i>), Ginger (<i>Zingiber officinale</i>), Colocasia (<i>Colocasia esculenta</i>) | Brinjal (<i>Solanum melongena</i>), Okra (<i>Abelmoschus esculentus</i>), Bitter gourd (<i>Momordica charantia</i>), Ridge gourd, Chilli (<i>Capsicum annum</i>), Greens (<i>Amaranthus</i> spp), Cowpea (<i>Vigna unguiculata</i>) | Tomato (<i>Solanum lycopersicum</i>), Brinjal (<i>Solanum melongena</i>), Cauliflower (<i>Brassica oleracea</i> var. <i>botrytis</i>), Greens (<i>Amaranthus</i> spp) | Brinjal (<i>Solanum melongena</i>), Chilli (<i>Capsicum annum</i>), Pumpkin (<i>Cucurbita maxima</i>), Greens (<i>Amaranthus</i> spp) |
| T ₁₃ (1.3 acre) | | Paddy (<i>Oryza sativa</i>) | | |
| T ₁₄ (1.4 acre) | | Paddy (<i>Oryza sativa</i>) | | |
| T ₁₅ (1.5 acre) | | Paddy (<i>Oryza sativa</i>) | | |

plots. No seasonal crop was found to be grown beyond 1.2 acre in summer. It was observed that crop diversity is more up to 1.2 acre size holdings because these holdings were mostly the homesteads and there is water source where people grow the food crops essential for them and mostly managed by the family labour. On the other hand in relatively higher holding sizes which are more than 1.2 acre, paddy is grown in kharif with the coconut trees which are located in the bunds of paddy field. Raising of different seasonal crops has also been reported by Nair (1984), Manjunath *et al.* (1998) and Isacc and Nair (2008) with coconut.

Livestock in coconut based agroforestry/farming system

The livestock comprising animals and birds was found

to be an integral part in most of the holding sizes in coconut-based farming system of the district (Table 3). The animals included cattle, buffalo and goat among which cattle was common in all size holding. The cattle number varied from 2 to 4 per holding with relatively higher number in higher holdings. Keeping of cattle is very common in rural areas of Odisha for milk and draught purpose. Relatively more number is found where area is more to be ploughed. The buffalo were found in holding size of 0.3 acre to 1.3 acre numbering 2 to 3 per holding. In relatively small size holding those were not found because there is no space for ploughing. In case of bigger holdings those were not found may be due to mechanized farming. The goats were found in holding size of 0.1 acre to 0.9 acre. This indicates that small farmers

Table 3 Livestock composition in coconut-based farming system in Puri district of Odisha

| Treatment (Holding size) | Number of animals | | | Number of birds | | | |
|--------------------------------|-------------------|---------|------|-----------------|---------|------|-------|
| | Cattle | Buffalo | Goat | Total | Poultry | Duck | Total |
| T ₁ (0.1 acre) | 2 | 0 | 2 | 4 | 6 | 5 | 10 |
| T ₂ (0.2 acre) | 2 | 0 | 3 | 5 | 6 | 4 | 9 |
| T ₃ (0.3 acre) | 2 | 0 | 4 | 6 | 6 | 4 | 10 |
| T ₄ (0.4 acre) | 2 | 2 | 3 | 7 | 5 | 4 | 9 |
| T ₅ (0.5 acre) | 2 | 2 | 3 | 7 | 5 | 3 | 8 |
| T ₆ (0.6 acre) | 3 | 2 | 3 | 8 | 5 | 3 | 8 |
| T ₇ (0.7 acre) | 3 | 2 | 3 | 8 | 4 | 3 | 7 |
| T ₈ (0.8 acre) | 3 | 2 | 4 | 9 | 4 | 3 | 7 |
| T ₉ (0.9 acre) | 4 | 2 | 2 | 8 | 0 | 5 | 5 |
| T ₁₀ (1.0 acre) | 4 | 3 | 0 | 7 | 0 | 4 | 4 |
| T ₁₁ (1.1 acre) | 4 | 2 | 0 | 6 | 0 | 3 | 3 |
| T ₁₂ (1.2 acre) | 4 | 2 | 0 | 6 | 0 | 2 | 2 |
| T ₁₃ (1.3 acre) | 4 | 2 | 0 | 6 | 0 | 0 | 0 |
| T ₁₄ (1.4 acre) | 4 | 0 | 0 | 4 | 0 | 0 | 0 |
| T ₁₅ (1.5 acre) | 4 | 0 | 0 | 4 | 0 | 0 | 0 |
| SEm _(±) | 0.37 | 0.37 | 0.58 | 0.44 | 0.36 | 0.27 | 0.21 |
| CD (P=0.05) | 1.09 | 1.08 | 1.68 | 1.28 | 1.03 | 0.79 | 0.61 |

having less land are preferring goat and the number varies 2-4 per holding. The total number of animals per holding varied from 4-9 with relatively more number between 0.4 and 1.0 acre. This may be due to the fact that the middle size holdings are preferring all three types of livestock. Integration of livestock in coconut-based agroforestry system has also been reported by Nair (1984). With regards to birds, poultry and ducks were found to be reared in different sizes of holding, 4-6 number of poultry birds were found up to the holding size 0.8 acre. This signifies that the small farmers having relatively small area are integrating the poultry bird to enhance their income. Ducks were found to be reared in 2 to 5 numbers in the holding size varying from 0.1 acre to 1.2 acre.

This is because ponds are available in the backyards and ducks are reared easily for egg and meat. Beyond 1.2 acre holding sizes which are mostly paddy fields ducks are not found because of absence of pond. The total numbers of birds in terms of poultry and duck varied from 2 to 10 in holding size of 0.1 acre to 1.2 acre. Significantly, higher number of birds were found in relatively smaller size holding because people try to enhance their income by integrating more number of birds in their small size holdings. Rearing of birds in coconut based agroforestry has also been reported by Jhon and Nair (1999), Ahmed and Hazarika (2007) and Nair (2008).

Pisciculture in coconut-based farming system

In costal district like Puri presence of pond is a common feature in the homestead which provides scope for pisciculture in coconut-based farming system (Table 4). It

Table 4 Pisciculture in coconut-based agroforestry system in Puri district of Odisha

| Treatment (Holding size) | Size of fish pond in acre | Number of fish species | Name of major fish species |
|-----------------------------|---------------------------------|---------------------------|----------------------------------|
| T ₁ (0.1 acre) | 0.03 | 2 | Rohu and silver carp |
| T ₂ (0.2 acre) | 0.05 | 2 | Rohu and silver carp |
| T ₃ (0.3 acre) | 0.05 | 2 | Rohu and silver carp |
| T ₄ (0.4 acre) | 0.07 | 2 | Rohu and silver carp |
| T ₅ (0.5 acre) | 0.10 | 3 | Rohu, Silver carp, Grass carp |
| T ₆ (0.6 acre) | 0.11 | 3 | Rohu, Silver carp, Grass carp |
| T ₇ (0.7 acre) | 0.15 | 3 | Rohu, Silver carp, Grass carp |
| T ₈ (0.8 acre) | 0.17 | 3 | Rohu, Silver carp, Grass carp |
| T ₉ (0.9 acre) | 0.17 | 3 | Rohu, Silver carp, Grass carp |
| T ₁₀ (1.0 acre) | 0.17 | 3 | Rohu, Silver carp, Grass carp |
| T ₁₁ (1.1 acre) | 0.15 | 3 | Rohu, Silver carp, Grass carp |
| T ₁₂ (1.2 acre) | 0.10 | 3 | Rohu, Silver carp, Grass carp |
| T ₁₃ (1.3 acre) | 0.00 | 0 | |
| T ₁₄ (1.4 acre) | 0.00 | 0 | |
| T ₁₅ (1.5 acre) | 0.00 | 0 | |

was observed that fish pond of size 0.03 acre to 0.17 acre was available in the homesteads around which coconut and other trees were grown.

Relatively higher size of pond was found between 0.4 acre to 1.2 acre holding size. Beyond 1.2 acre size holding ponds are not available because these are paddy fields and fish cultivation is not practised. Two to three numbers of fish species were found to be cultivated by people and they were mostly rohu (*Labeo rohita* L.), silver carp and grass carp (*Ctenopharyngodon idella*). People grow these species for home consumption in case of small size pond and some extend for sale in higher size pond.

Mushroom cultivation in coconut-based farming system

Integration of paddy straw mushroom (*Volvariella volvacea*) during March to October and oyster mushroom (*Pleurotus sajor-caju*) during November to February is increasing in the coconut-based farming system in Puri district. It was observed that holding size of 0.4 acre to 1.00 acre are accommodating mushroom cultivation under the canopy of coconut (Table 5). This indicates that farmers having medium size holding around their homestead are preferring mushroom cultivation. The reason is that the microclimate under canopy of coconut is suitable for paddy straw mushroom and there is a good market for the mushroom due to presence of nearby cities like Bhubaneswar, Cuttack and Puri.

Table 5 Mushroom cultivation in coconut-based agroforestry system in Puri district of Odisha

| Treatment (Holding size) | Number of beds 1 bags | Number of mushroom species | Name of mushroom species |
|-----------------------------|-----------------------------|----------------------------------|-----------------------------|
| T ₁ (0.1 acre) | 0 | 0 | |
| T ₂ (0.2 acre) | 0 | 0 | |
| T ₃ (0.3 acre) | 0 | 0 | |
| T ₄ (0.4 acre) | 143 | 2 | Paddy straw/Oyester |
| T ₅ (0.5 acre) | 192 | 2 | Paddy straw/Oyester |
| T ₆ (0.6 acre) | 240 | 2 | Paddy straw/Oyester |
| T ₇ (0.7 acre) | 255 | 2 | Paddy straw/Oyester |
| T ₈ (0.8 acre) | 255 | 2 | Paddy straw/Oyester |
| T ₉ (0.9 acre) | 258 | 2 | Paddy straw/Oyester |
| T ₁₀ (1.0 acre) | 260 | 2 | Paddy straw/Oyester |
| T ₁₁ (1.1 acre) | 0 | 0 | |
| T ₁₂ (1.2 acre) | 0 | 0 | |
| T ₁₃ (1.3 acre) | 0 | 0 | |
| T ₁₄ (1.4 acre) | 0 | 0 | |
| T ₁₅ (1.5 acre) | 0 | 0 | |

Table 6 Contribution of coconut-based farming system towards fuel and other wood consumption

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

Role of coconut-based farming system on livelihood

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 institutions give coconut a very sacred place in this part of Odisha since long time. Coconut based farming systems are playing multiple roles like various productive, protective 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 CO₂ sink, restoring soil productivity, provides shade, moderating temperature, reducing wind speed, creating congenial microclimate, 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 to large holdings as well as cash in large holdings. Many researchers also have highlighted such roles of homestead farming systems (Rahman *et al.* (2013), Nair (2008) Ahmed and Rahman (2004), Arunachalam *et al.*(2007) and Mohapatra *et al.* (2007). However, in comparatively large holdings which are more than 1.2 acre where species diversity is less, the role of the coconut based agroforestry system is also comparatively less.

Contribution of coconut-based farming system towards wood production

The Puri district of Odisha is away from the natural forests. People in rural areas mostly depend on homesteads to meet their wood requirement. Therefore, coconut-based

agroforestry system plays an important role in contribution of fuel and other wood requirements (Table 6). It was observed that contribution of different holding sizes of coconut-based agroforestry system varied from 7.6% to 49.2% of the total wood consumption of house. The contribution went on increasing from 0.1 acre size to 1.2 acre size. This may be due to availability of more wood from coconut and other perennial species. Beyond 1.2 acre the contribution was 37.4% to 44.8% because more wood was obtained from coconut trees. Getting of energy from homestead has also been reported by some researcher like Ahmed and Rahman (2004), Mohiuddin *et al.* (1999), Millat *et al.* (1994), Ahmed and Rahman (2004), Rahman *et al.* (2013) and Ahmed and Hazarika (2007).

Economics of coconut-based farming system

The coconut based agroforestry system in Puri district of Odisha is playing a significant role towards the economics of the households as evident from Table 7 and Fig 1.

The cost involved in the system per holding in a year varied significantly among different holding sizes which ranged from ₹ 5600 to ₹ 33417. The cost involved per holding increased from 0.1 acre to 0.8 acre size with increase of holding size. This is due to increased area of operation, however the cost involvement per holding decreased from 0.9 acre to 1.5 acre which may be ascribed to reduction in diversity towards higher size holdings. In terms of cost involved per acre basis it ranged from ₹ 19311 to ₹ 56000. It decreased towards higher holding size which may be due to reduction of species and component diversity towards higher holding sizes. The gross return exhibited similar trend like cost involved per holdings. The gross return per acre also reflected similar trend like cost involved per acre.

Table 7 Economics of coconut-based farming system

| Treatment (Holding size) | Cost involved (₹) | | Gross return (₹) | | Net return (₹) | | B : C ratio | Market Orientation of produce (home consumption: sale) |
|-----------------------------|----------------------|----------|---------------------|----------|-------------------|----------|----------------|--|
| | Per holding | Per acre | Per holding | Per acre | Per holding | Per acre | | |
| T ₁ (0.1 acre) | 5 600 | 56 000 | 11 217 | 112 167 | 5 617 | 56 167 | 2.00 | 100 : 0 |
| T ₂ (0.2 acre) | 10 410 | 52 050 | 21 363 | 106 817 | 10 953 | 54 767 | 2.05 | 100 : 0 |
| T ₃ (0.3 acre) | 15 260 | 50 867 | 30 847 | 102 822 | 15 587 | 51 956 | 2.02 | 96 : 4 |
| T ₄ (0.4 acre) | 19 228 | 48 071 | 38 733 | 96 833 | 19 505 | 48 763 | 2.01 | 85 : 15 |
| T ₅ (0.5 acre) | 23 227 | 46 453 | 45 667 | 91 333 | 22 440 | 44 880 | 1.97 | 80 : 20 |
| T ₆ (0.6 acre) | 27 647 | 46 078 | 53 530 | 89 217 | 25 883 | 43 139 | 1.94 | 75 : 25 |
| T ₇ (0.7 acre) | 30 560 | 43 657 | 59 893 | 85 562 | 29 333 | 41 905 | 1.96 | 69 : 21 |
| T ₈ (0.8 acre) | 33 417 | 41 771 | 67 893 | 84 867 | 34 477 | 43 096 | 2.03 | 61 : 29 |
| T ₉ (0.9 acre) | 31 550 | 35 056 | 65 700 | 73 000 | 34 150 | 37 944 | 2.08 | 54 : 46 |
| T ₁₀ (1.0 acre) | 30 367 | 30 367 | 64 167 | 64 167 | 33 800 | 33 800 | 2.11 | 47 : 53 |
| T ₁₁ (1.1 acre) | 30 533 | 27 758 | 64 117 | 58 288 | 33 583 | 30 530 | 2.10 | 45 : 55 |
| T ₁₂ (1.2 acre) | 30 400 | 25 333 | 63 717 | 53 097 | 33 317 | 27 764 | 2.10 | 42 : 58 |
| T ₁₃ (1.3 acre) | 29 833 | 22 949 | 63 167 | 48 590 | 33 333 | 25 641 | 2.12 | 34 : 66 |
| T ₁₄ (1.4 acre) | 29 617 | 21 155 | 62 700 | 44 786 | 33 083 | 23 631 | 2.12 | 24 : 76 |
| T ₁₅ (1.5 acre) | 28 967 | 19 311 | 61 817 | 41 211 | 32 850 | 21 900 | 2.13 | 15 : 85 |
| SEm(±) | 232 | 266 | 600 | 572.00 | 592 | 578 | 0.02 | 3 : 0.6 |
| CD (P=0.05) | 671 | 770 | 1 766 | 1 673 | 1 716 | 1 673 | 0.07 | 9 : 1 |

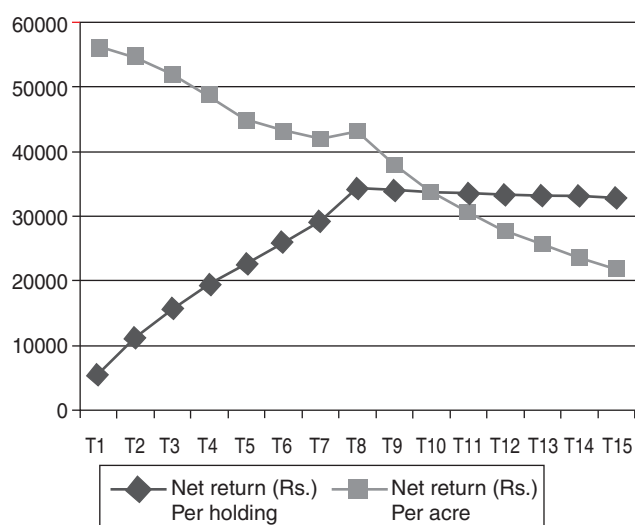


Fig 1 Net return of coconut-based farming system

The gross return per holding ranged from ₹ 11 270 to ₹ 67 897, whereas per acre it ranged from ₹ 41 211 to ₹ 112 167. The net return per holding showed significant variation among the treatment. It ranged from ₹ 5 617.00 (T₁) to ₹ 34 477.00 (T₈). The net return per holding progressively increased from T₁ to T₈. This may be because of increase in unit size having diversity of components. On the other hand net return per holding decreased from T₉ (₹ 34 150) to T₁₅ (₹ 32 850) with increase in holding size. This has happened may be due to reduction in species and component diversity in the coconut based agroforestry system. With regards to net return per acre basis the value

varied from ₹ 56 167 to ₹ 21 900. The net return per acre decreased steadily from T₁ to T₁₅ with increase of holding size. This may be attributed to decrease in diversity and components towards higher holding size. The B:C ratio varied from 1.94 to 2.13 under different holding sizes. Relatively higher ratio was obtained in higher holdings may be due to more mechanization of the farming. Economics of coconut-based farming system has also been reported by some researcher like Maheswarappa *et al.* (2000) and Pires *et al.* (2004).

The coconut-based farming system of Puri district of Odisha is found to be rich with regard to floral composition and livelihood support. The holdings up to 1.2 acre size are found to be well composed of various types of plants such as tree species, fruit plants and seasonal crops along with coconut in four different strata. The livestock such as cattle, buffalo, goat, ducks and poultry are associated in most of the coconut-based farming systems. Coconut based farming systems particularly up to 1.2 acre size are contributing various types of tangible and intangible benefits to the households including food, fuel, timber, fodder, oil, thatching and broom material, cash, employment, shade, good microclimate, habitat for birds, learning ground for children, aesthetic, cultural and religious values. The net return was assessed to be ₹ 5 617 to ₹ 34 770 per annum depending on the holding size from 0.1 to 1.5 acre. The contribution of coconut based system towards wood production was found significant. The coconut-based agroforestry system of size 0.8 acre was found to be best among the holding sizes studied with regard to viability of land use.

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