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Spatio temporal arrangement of plants and livestock in the home gardens of coastal Odisha

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Abstract
This paper presents a study carried out in Balasore district of Odisha during June 2012 – May 2013 to determine the distribution of plants and livestock in 11 different sizes (0.1 to 1.1 acre) of home gardens. The home gardens in the study area were found to be composed of a mixture of perennials, annuals, seasonal plants, medicinal plants live fencing plants. There are four different canopy layers i.e. Top storey (> 10m), Middle Story (5-10m), Lower storey (2-5m) and Ground Cover (<2m). The number of perennial species found in the home gardens ranged from 8-18, annuals ranged from 2-7 and seasonal plants ranged from 4-9. Tree density decreased from 60 plants/acre to 38 plants/acre with increase in homegarden size (0.1 to 1.1 acre). Similarly, the total number of livestock animals decreased from 18 (0.1 acre) to 4 (1.1 acre) with increase in homegarden size. Regular spatial arrangement of plants was found in home gardens of size 0.5 or more. The organic carbon content of soil has registered a similar trend i.e. Organic Carbon content (%) decreased from 0.68% to 0.48% with increase in size of homegarden. Overall, homegarden of 0.5-0.8 acre size were found to be the better ones with regard to spatio-temporal arrangement and soil health.

Keywords: Homegarden, agroforestry, composition, economics, Odisha

1. Introduction
A home garden is a piece of land with a definite boundary surrounding a homestead, being cultivated with a diverse mixture of perennial and annual plant species, arranged in a multilayered vertical structure, often in combination with raising livestock, and managed mainly by household members for subsistence production (Christanty, 1990[10]; Fernandes and Nair, 1986[11]; Hoogerbrugge and Fresco, 1993[14]; Kumar and Nair, 2004[17]; Rugalema *et al*., 1994[28] and Soemarwoto, 1987[33]). In India, the home gardens are generally found in tropical and sub-tropical areas and characterized by high species diversity and usually three to four vertical canopy strata. These consist of an herbaceous layer near ground, a tree layer at the upper level and one to two intermediate layers. In addition to these components, livestock also contributes significantly to the household income of small-scale home gardens in many developing countries, while fulfilling many social and cultural needs (Wilson, 1995[36]). Almost every backyard in coastal Odisha, West Bengal and Assam also has a small pond used for ablutions, growing aquatic leafy vegetables, fish, supplement of irrigation and to absorb flood. Home gardens are well-established land use systems in Bangladesh where different crops, including trees, are grown in combination with livestock and fish. According to a study by the National Institute of Agricultural Marketing (NIAM, Jeypore) as many as 75% to 80%, farmers have homestead gardens in Assam.
This agroforestry system is very old and found in variable forms in all districts of Odisha. More intensive forms of this practice are seen commonly in coastal districts like Balasore, Bhadrak, Puri, Jagatsinghpur and Kendrapara. 'Bari' (backyard) farming is a common practice in Odisha. In Odisha, 'ghar' (house) is incomplete without 'bari' (backyard). Like other areas, a common backyard or homestead in Odisha consists of trees, herbaceous crops, livestock sheds along with additional features like threshing yard, fuel wood stack, toilet, etc. In coastal Odisha, pond is a common feature. Basing on this background, an attempt was taken to study both the spatial and temporal arrangement of home gardens in coastal Odisha.

2. Materials and Methods
The present study was carried out in the Balasore district of Odisha, a coastal district along the Bay of Bengal during June 2012 - May 2013. The experiment was laid out in Randomised Block Design (RBD) with three replications. For this the district was divided into three regions, each region representing one replication. The treatments were homestead agroforestry system under eleven different holding sizes such as 0.1 acre, 0.2 acre, 0.3 acre, 0.4 acre,

0.5 acre, 0.6 acre, 0.7 acre, 0.8 acre, 0.9 acre, 1.0 acre and 1.1 acre. From each replication, 33 sample plots were selected from four different villages located closely and made into 11 composite samples, one for each treatment. The observations were recorded on species composition, number of trees, number of livestock animals and birds and soil condition of homegardens.

3. Results and Discussion

i. Floral composition of homegardens

The common perennial plants differed appreciably among different sizes of home gardens. In small home gardens upto 0.2 acre, the common perennial plants were mango, guava, drumstick, papaya, lemon, curry leaf, banana and tamarind. Whereas, additional plants like acacia, bamboo and custard apple were found in home garden size of 0.3 acre with further addition of neem and coconut in 0.4 acre size. With increase of home garden size 0.5 acre to 1.1 acre, the common perennial plants grown were mango, coconut, guava, drumstick, jackfruit, bael, papaya, lemon, banana, custard apple, curry leaf, tamarind, teak, eucalyptus, neem, acacia and bamboo. Irrespective of home garden size, the most frequently grown perennial plants were mango, guava, drumstick, papaya, lemon, curry leaf, banana and tamarind. This may be because of dependency of people on these plants in day to day life. The addition of different species in home garden of higher size may be attributed to increase of area to accommodate more species and/or to generate commercial value from different species. Alam and Sarker (2011) [3], Shumba *et al*. (1998) [32], Alam *et al*. (2005) [5], Ahmed and Rehman (2004) [2] and Miah and Rahman (2004) [18] have reported similar findings.

In all sizes of homegardens seasonal crops were found to be grown throughout the year. In small home gardens upto 0.2 acre the common kharif crops were brinjal, okra, ivory gourd, bitter gourd, chilli, spinach and greens where as in holding size 0.4 acre and above the additional crops were maize, cucumber and cowpea. Similarly in rabi season the common crops raised were tomato, brinjal, cabbage, cauliflower, onion and marigold. With increase in holding size the horticultural crops added were beans, radish, carrot and greens. In higher size homegardens potato and garlic were added. In summer season the crops which are generally raised include brinjal, chilli, pumpkin and greens with addition of okra in 0.5 acre size and onwards. Nair (2008) [25] has also reported that food production is almos continuous throughout the year. This suggests that people are very much dependent on home gardens for food production. Senaid *et al*. (2004) [30] have observed that home garden size of 500 to 1000m2 is enough to partially satisfy the needs of a family of 4 in terms of fruits and vegetables. Another reason may be easy access of the home garden for utilization of family labour throughout the year and assured protection of the home garden from biotic interference and adverse climatic factors.

Among the common medicinal plants occimum and vasaka were found to be frequently grown by people of all holding size. This is because of high medicinal values of these two plants. In addition to this, occimum was found frequently because of strong religious value of the plant for Hindu community which has also been deliberated by Miah and Rahman (2004) [18].

In all home gardens irrespective of sizes live fence has been erected. The common species were *Euphorbia caducifolia, Jatropha curcus* and *Adhatoda vassica*. The plants were preferred because these are non-browseable species and easy to establish.

ii. Number of Common plant species

The data pertaining to number of plants grown in different sizes of homestead agroforestry varied remarkably (Table-1) of Fig. 4.2. The number of perennial plant species grown varied from 8 to 18. The number increased gradually up to 0.5 acre (17 nos.) and then the number was almost similar in higher size holdings with slight increase of one number in 0.9 acre to 1.1 acre (18nos.). The number of annual plant species grown in homestead under study varied from 2 to 7.

The number of seasonal plants witnessed little variation among the holding sizes. In kharif, the number of seasonal crops ranged from 7 to 9. The holding size 0.1 to 0.3 acre recorded 7 nos. of kharif crops while the rest of the holding sizes recorded 9 nos. of crops. In rabi season, the number of crops grown ranged from 7 to 9. With regard to summer season, 4 crops were found in unit size of 0.1 acre to 0.4 acre and 5 nos. of crops were found in rest of the holding sizes. The total number of seasonal crops comprising kharif, rabi and summer season varied from 19 to 22. Maximum number of crops was found to be grown in unit size of 0.4 to 0.8 acre.

Table 1: Common plant species in homegardens in Balasore district of Odisha

Treatment (Homegarden size)	Perennial species	Annual species	Common Seasonals				Common medicinal plants	Live fence plants	Grand Total
			Kharif	Rabi	Summer	Total			
T_1 (0.1acre)	8	2	7	8	4	19	2	2	33
T_2 (0.2acre)	8	3	7	9	4	20	2	2	36
T_3 (0.3acre)	11	6	7	9	4	20	2	2	41
T_4(0.4acre)	13	6	9	9	4	22	2	2	45
T_5(0.5acre)	17	7	9	8	5	22	2	2	50
T_6(0.6acre)	17	7	9	8	5	22	2	2	50
T_7(0.7acre)	17	7	9	8	5	22	2	2	50
T_8(0.8acre)	17	6	9	8	5	22	2	2	49
T_9(0.9acre)	18	5	9	7	5	21	2	2	48
T_{10}(1.0acre)	18	5	9	7	5	21	2	2	48
T_{11}(1.1acre)	18	5	9	7	5	21	2	2	48
SEm(±)	0.54	0.60	-	-	-	-	-	-	0.59
$CD_{(0.05)}$	1.59	1.79	NS	NS	NS	NS	NS	NS	1.75

The common medicinal plants were two in number i.e. occimum and vasaka in all holding sizes studied. The number of common plants raised for live fence was 2 i.e. jatropha and milk hedge plant in all units irrespective of sizes. In addition to these two plants, vasaka which has been put under common medicinal plant was also a common live fence plant.

The grand total number of common plant species comprising perennials, annuals, seasonals, medicinal plants and live fence plants differed significantly among various holding sizes. The number ranged from 33 to 50. The lowest number of plants was found in 0.1 acre where as highest number of plants was observed in 0.5 to 0.7 acre size. However, the diversity of plants increased from 0.1 acre to 0.5 acre, the results are in line with the finding of Rahman *et al*., (2013) [26], Misbahuzzaman and Ahmed (1993) [20] and Ahmed and Rahman (2004) [2].

iii. Number of trees in homegardens

The number of trees found in home gardens of different sizes varied significantly (Table-2). The number of trees under different height classes was remarkably different in different holding sizes. In all height classes i.e. 5-10 m., 10-15m and more than 15m, the number of trees increased with increase of holding size from 0.1 to 1.1 acre although in higher holdings (0.9 acre and above) the values were statistically alike. On the other hand while the number of trees was compared on acre basis, the trend was different. In 5-10 m height class more trees (15 to 18) were found from T_2 to T_6 on acre basis and in height class of 10-15 m more trees per acre (17 to 30) were found in T_1 to T_6. In more than 15 m height class, more number of trees per acre was found in T_1 (20) and T_4 (17). While the total number of trees was taken into account including all height classes per holding, the number of trees ranged from 6 to 42 increasing with holding size, but it showed reverse trend when calculated per acre basis i.e. 38 to 60 witnessing significantly more number of trees per unit area in lower size holdings. On the other hand the density of trees was higher in smaller size home gardens. The results are in line with the findings of John and Nair (2002) [15] and Ahmed and Rahman (2004) [2].

Table 2: Number of trees in homegardens of Balasore district of Odisha

Treatments (Home garden Size)	Height class						Total	
	5m-10m		10m-15m		>15m			
	In holding	Per acre	In holding	Per acre	In holding	Per acre	In holding	Per acre
T_1(0.1ac)	1	10	3	30	2	20	6	60
T_2(0.2ac)	3	15	5	25	3	15	11	55
T_3(0.3ac)	5	17	7	23	4	13	16	53
T_4(0.4ac)	6	15	7	18	7	17	20	50
T_5(0.5ac)	9	18	8	16	7	14	24	48
T_6(0.6ac)	9	15	10	17	9	14	28	46
T_7(0.7ac)	10	14	11	16	9	13	30	43
T_8(0.8ac)	10	13	13	16	10	12	33	41
T_9(0.9ac)	12	13	13	14	11	13	36	40
T_{10}(1.0ac)	12	12	13	13	14	14	39	39
T_{11}(1.1ac)	13	12	15	14	14	12	42	38
SEm(±)	0.59	0.55	0.6	0.4	1.19	1.24	0.54	4.30
$CD_{(0.05)}$	1.73	1.62	1.76	1.19	3.51	3.67	1.6	12.68

iv. Plants species stratification

The stratification of plants species in different sizes of homestead agroforestry systems is depicted in Table-3. It was observed that in all 11 sizes of homestead agroforestry system the plants have been categorized into 4 strata i.e. more than 10m, 5-10m, 2-5m and less than 2m height from ground level which can be designated as top storey, middle storey, lower storey and ground cover respectively. In more than 10m storey the number of plants varied in different unit sizes and the common species are tamarind, mango and drumstick, acacia, jackfruit, neem and bamboo

In middle storey (5-10m), the common trees observed growing were dwarf mango and guava and bael. With regard to lower storey (2-5m), the plants species were banana, papaya, custard apple and curry leaf.

As far as the ground cover (<2m) is concerned, the number of plants species were somewhat different in different holding sizes. The number of plants recorded in this layer was 23 in 0.1 acre, 25 each in 0.2 and 0.3 acre and 27 in 0.4 acre, while the number was 28 in rest of the holding sizes. All the common annual crops, seasonal crops, medicinal plants and live fence plants irrespective of holding sizes found in this category. Different plants have occupied different strata may be due to their growth rate, light requirement and arrangement made by the grower to intensify the land use system and explore maximum benefit. Similar studies have also been reported by Rahman *et al.,* (2013) [26], Nair (2008) [25] and Fernandes *et al.,* (1984) [12].

Table 3: Plant species stratification

Treatment (Homegarden size)	Top Storey (>10m)	Middle storey (5-10m)	Lower storey (2-5m)	Ground cover (< 2m)
T_1 (0.1acre)	2	3	3	23
T_2 (0.2acre)	3	2	4	25
T_3 (0.3acre)	5	2	4	25
T_4(0.4acre)	7	2	4	27
T_5(0.5acre)	10	3	4	28
T_6(0.6acre)	10	3	4	28
T_7(0.7acre)	10	3	4	28
T_8(0.8acre)	10	3	4	28
T_9(0.9acre)	10	3	4	28
T_{10}(1.0acre)	10	3	4	28
T_{11}(1.1acre)	10	3	4	28

v. Spatial arrangement of plants

The spatial arrangement of different components such as perennial plants, annual plants, seasonal plants, medicinal plants and live fence plants varied remarkably under different holding sizes. As far as the perennial plants are concerned, most of the plants were found to be irregularly arranged. Species like coconut, teak, acacia, eucalyptus and bamboo have been raised in relatively higher holding size of 0.5 acre or more were found under regular arrangement. This may be because of the fact that in higher holding sizes relatively more space is available for planning the homegarden in better way and planting such commercial tree species in regular order. At the same time such species were found arranged irregularly in smaller holdings (≤ 0.4 acre). The common perennial plants which were found in irregular spatial arrangement were mango, guava, drumstick, jackfruit, bael, papaya, lemon, banana, curry leaf, custard apple, tamarind and neem. The reason behind the irregular arrangement may be due to natural regeneration of some plants, planting in different times without long term plan and wish to accommodate more number of plants in limited space. With regard to annual plants excepting yam other plants were found to be arranged in regular order in different holding sizes. The annual plants found in regular arrangement were turmeric, pineapple, arrowroot, ivory gourd, colocasia and ginger. The reason may be that these plants are planted every year and the people get chance to grow them in regular order for getting maximum return. The yam was found in irregular arrangement because people generally put it randomly in the place where it can get support to climb. With respect to the seasonal plants, it was observed that all plants were found to be grown in regular spatial arrangement in all holding sizes. The common seasonals included brinjal, okra, bitter gourd, ridge gourd, cowpea, chilli, spinach, cucumber, tomato, cabbage, cauliflower, radish, onion, carrot, pumpkin, greens and marigold. The reason of regular spatial arrangement may be attributed to short life span of the plant by which people gain enough experience to grow them with proper spatial arrangement to explore more benefit. The common medicinal plants such as occimum and vasaka were found to be grown in irregular arrangement in all holding sizes. Similar the case in live fence plants such as jatropha and milk hedge. Roy *et al*., (2013) [27] has also pointed out the irregular spatial arrangement of plants in homegardens of Bangladesh.

vi. Number of livestock animals and birds in homegardens

The livestock component was found in each home garden size. Various types of livestock such as cattle, buffalo, sheep, goat, ducks and poultry were found to be integrated in most of the holding sizes (Table 4). The number of cattle ranged from 2 to 5 with higher number (5) in comparatively small holdings (T_1 to T_4) and the number gradually reduced towards higher holdings. On the other hand buffalo was not found to be kept by small holdings (T_1 to T_3) and the number was two each in holding size of 0.4 acre and onwards. The sheep reared was found to be limited within 0.7acre size with a decreasing trend from T_1 to T_7. More or less similar trend was observed in case of goat although the number varied from 5-9 per holding. In total the number of animals varied significantly among different holding sizes ranging from 4 to 18. The highest number of animals (18) was recorded in the smallest holding under study (T_1). The total number of animal steadily decreased upto T_9 (4 numbers) and beyond that it was same. This indicated that smaller animals like Sheep and Goat which are generally reared for meat and milk are more preferred by people having small holding sizes comparatively. The buffalos were mostly found in 0.4 acre size and above. It was observed that smaller holdings are more depended on animals than the bigger holdings. The bigger holdings rear less animals may be because of their tendency towards

Table 4: Number of livestock animals and birds in homegardens of Balasore district of Odisha

Treatments (Homegarden size)	Number of animals					Number of birds		
	Cattle	Buffalo	Sheep	Goat	Total	Ducks	Poultry	Total
T_1(0.1ac)	5	0	4	9	18	0	4	4
T_2(0.2ac)	5	0	3	8	16	0	5	5
T_3(0.3ac)	5	0	2	6	13	0	5	5
T_4(0.4ac)	5	2	2	6	15	4	4	8
T_5(0.5ac)	4	2	2	6	14	4	5	9
T_6(0.6ac)	4	2	2	5	13	6	0	6
T_7(0.7ac)	3	2	1	5	11	6	0	6
T_8(0.8ac)	3	2	0	0	5	6	0	6
T_9(0.9ac)	2	2	0	0	4	7	0	7
T_{10}(1.0ac)	2	2	0	0	4	7	0	7
T_{11}(1.1ac)	2	2	0	0	4	8	0	8
SEm(±)	0.35	0.15	0.43	0.57	1.06	0.4	0.4	0.51
$CD_{(0.05)}$	1.05	0.44	1.26	1.71	3.18	1.21	1.19	1.54

Modernization and mechanization in agriculture. With regard to number of birds, ducks were found to be reared in holding sizes 0.4 acre and more and the number varied from 4 to 8. This may be due to availability of backyard ponds in home gardens of higher size. On the contrary poultry birds were reared in small holdings limited up to 0.5 acre size. The people having small holdings are generally economically poor and rear poultry birds. Rearing of such animals and birds in home gardens has also been reported by Alam and Masum (2005) [4], Nair and Sreedharan (1986) [24], John and Nair (1999) [16], Ahmed and Hazarika (2007) [1], Sahoo (2007) [29] and Arunachalam *et al.* (2007) [7].

vii. Soil status under homestead agroforestry system

The soil chemical status under homestead agroforestry system of different sizes varied significantly (Table 5). The organic carbon content varied remarkably in different unit sizes. T_1 registered the highest value (0.68%) while T_{11} registered the lowest value (0.48%). The organic carbon content decreased with increase of holding size. However, parity in values was observed in case of T_2 and T_3, T_4 and T_5, T_6, T_7 and T_8 and T_{10} and T_{11}. Comparatively more litter was accumulated in smaller size homegardens. The results are supported by findings of Hazra and Tripathy (1986) [13], Sharma and Gupta (1989) [31] and Murthy *et al.,* (1990) [23].

The P^H of soil under different holding sizes differed appreciably (Table 6). The P^H value ranged from 5.48 to 7.13. T_{11} registered maximum P^H of 7.13 where as T_1 registered the minimum P^H of 5.48. The values were statistically at par with each other in case of T_1 to T_6 and T_4 to T_{11}. The values were relatively more in higher size holdings.

The available nitrogen status in soil was found remarkably different under different homegarden sizes. It varied from 268.65 to 312.63 kg ha^{-1} among the treatments. The maximum amount was found under T_1 and minimum under T_{11}. However, the values of T_1, T_2, T_3 were statistically alike. Similar thing was found among the treatments which are near to one another. The content of available nitrogen per hectare gradually decreased from T_1 to T_{11} with increase of homestead size.

Table 5: Soil status under homestead agroforestry system

Treatments (Homegarden size)	O.C. (%)	P^H	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1(0.1ac)	0.68	5.48	312.63	39.23	160.52
T_2(0.2ac)	0.62	5.5	306.37	36.67	158.12
T_3(0.3ac)	0.6	5.9	302.64	35.05	154.48
T_4(0.4ac)	0.57	6.03	296.11	34.65	152.82
T_5(0.5ac)	0.56	6.09	293.6	34.35	149.76
T_6(0.6ac)	0.54	6.29	290.65	33.7	148.12
T_7(0.7ac)	0.54	6.34	285.17	33.27	146.56
T_8(0.8ac)	0.52	6.51	282.63	31.3	144.22
T_9(0.9ac)	0.52	6.86	275.17	30.89	140.32
T_{10}(1.0ac)	0.49	7.05	272.63	28.43	138.96
T_{11}(1.1ac)	0.48	7.13	268.65	28.23	137.02
SEm(±)	0.01	-	3.41	0.35	1.92
$CD_{(0.05)}$	0.03	NS	10.28	1.03	5.68

The phosphorus content in the soil varied significantly among the treatments. The homegarden of 0.1 acre size witnessed significantly higher phosphorus content (39.23 kg $ha.^{-1}$) over rest of the homegarden sizes. The lowest amount of phosphorus (28.23 kg $ha.^{-1}$) was estimated under homegarden of 1.1 acre size. However, this value was at par with homegarden of 1.0 acre size. Similarly parity was found among T_3, T_4 and T_5 and also among T_6 and T_7. The phosphorus content steadily decreased with increase in homegarden size.

The available potassium also witnessed significant variation among the homegardens of different sizes. It ranged from 137.0 to 160.52 kg $ha.^{-1}$. The small homegarden of 0.1 acre size scored highest amount of available potassium among the homegardens while the homegarden of 1.1 acre size recorded the lowest amount. However, the values of T_1 and T_2, T_2, T_3 and T_4, T_4, T_5 and T_6 and T_6, T_7 and T_8, T_9, T_{10} and T_{11} were statistically alike. The potassium content reduced from T_1 to T_{11}. This may be associated with release of more nutrients and their recycling in smaller holdings where plant density is comparatively more. The improvement in macronutrient status under tree cover has also been reported by various authors. Hazra and Tripathy (1986)[13] observed an increase of status of organic carbon, N, P, K, Ca and Mg and decrease of soil P^H under the plantation of *Leucaena leucocephala, Melia azadirach* and *Eucalyptus tereticornis*. Alexander (1989)[6] reported a higher amount of total N, exchangeable Ca, Mg and Na in the soil under canopy of *Acacia albida* than the soil of outside area.

4. Conclusion

The findings of the present study indicate that home garden is an important land use system in coastal Odisha and food production is the major objective. A great degree of difference was observed among the 11 treatments in terms of range of species, spatial arrangement, tree and livestock density and soil characteristics. Out of the 11 treatments, the homegarden of 0.5-0.8 acre area were found to be better ones with regard to spatio-temporal arrangement and soil health. Since the present study revealed that the tree density decreases with an increase in area, the farmers with more area should be advised to increase tree diversity through proper utilization of available resources.

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