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Integrated farming systems for sustainability in coastal ecosystem

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ABSTRACT

The growth rate in agriculture during the recent past is in a very slow pase in spite of the rapid economic growth in our country. The trend in productivity of major crops is either static or declining trend during the X Five-year plan. There is no scope for further increase of net sown area and the present scenario indicated a slight shift of area for other purposes like industrialization and urbanization. To sustain a positive growth rate in agriculture, a holistic approach is the need of the hour. The goal of sustainable agriculture is to conserve the natural resource base, protect the environment and enhance prosperity for a longer period. Farming systems is a set of agro-economic activities that are interrelated and interact among themselves in a particular agrarian setting. In diversified farming, though crop and other enterprises exist, the thrust is mainly to minimize the risk. While in the Integrated Farming Systems (IFS) a judicious mix of one or more enterprises along with cropping has a complimentary effect through effective recycling of wastes and crop residues and encompasses additional source of income to the farmers. IFS activity is focused round a few selected inter-dependent, inter-related and inter-linking production systems, based on crops, animals and related subsidiary professions. It is a rich source of species diversity, helps in soil building, preserve and improve ecological condition essential to long-term sustainability. It also enhances soil nutrient cycling and prevent proliferation of pests. In all the ecosystems, IFS approach with location specific models offer gainful employment and are highly profitable and sustainable. The models developed in the coastal ecosystem of Kerala are discussed. The agronomic, socio-economic and environmental advantages of IFS are vivid and appealing. These are potentially suitable to all categories of farmers.

Key words: Coconut, Cycling, Ecosystems, Integrated Farming Systems, Rice.

The growth rate of agriculture in the recent past is in a very slow phase in spite of the rapid economic growth in our country. Capital investment in agriculture was less than 10 % during the last 3-plans. This has reflected in the productivity of major crops which is either static or declining in most parts of the country. According to the Economic Survey of India, 2008, the growth rate of food grain production decelerated to 1.2 % during 1990-2007, lower than the population growth of 1.9 %. It is projected that in our country population will touch 1,370 million in 2030 and to 1,600 million by 2050. To meet the demand, we have to produce 289 and 349 mt of food grains during the respective periods. The current scenario in the country indicates that area under cultivation may further dwindle and more than 20 % of current cultivable area will be converted for other purposes by 2030.

The operational farm holding in India is declining and over 85 million out of 105 million are below the size of 1 ha (Mahapatra and Bapat, 1992). Because of the ever increasing population and decline in per caput availability of land in the country, practically there is no scope for horizontal expansion of land for agriculture. Only vertical expansion is possible by integrating farming components requiring lesser space and time and ensuring reasonable returns to farm families. The Integrated Farming Systems (IFS) therefore assumes greater importance for sound management of farm resources to enhance the farm productivity and reduce the environmental degradation, improve the quality of life of resource poor farmers and maintain sustainability. In order to sustain a positive growth rate in agriculture, a holistic approach is the need of the hour. The goal of sustainable agriculture is to conserve the natural resource base, protect the environment and enhance prosperity for a longer period of time. Farming system is a set of agro-economic activities that are inter-related which interact among themselves in a particular agrarian setting. Farming system is a mix of farm enterprises to which farm families allocate resources to efficiently utilize the existing enterprises for the productivity and profitability of the farm. These farm enterprises are crop, livestock, aquaculture, agroforestry and agri-horticulture (Sharma *et al.,* 1991).

In such diversified farming, though crop and other en-

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terprises coexist, the thrust is mainly to minimize the risk, while in IFS a judicious mix of one or more enterprises along with cropping there exist a complimentary effect through effective recycling of wastes and crop residues which encompasses additional source of income to the farmer. IFS activity is focused around a few selected interdependent, inter-related and interlinking production systems based on crops, animals and related subsidiary professions. Tiwari (1993) observed that in the IFS the yield would be inherently more sustainable because the waste of one enterprise becomes the input of another, leaving almost no waste to pollute the environment.

An agro-climatic zone is a land unit of major climate, suitable for a certain range of crops and cultivars where as an ecological region is an area of the earth characterized by distinct ecological responses to macro-climate, as expressed by soils, vegetation, fauna and systems (FAO, 1983). The National Bureau of Soil Survey and Land use Planning (NBSS & LUP) has classified the country into 21 zones in the agro-ecological maps with six ecosystems, viz. arid, semi-arid, sub-humid, humid-per humid, coastal and island ecosystems. Though, subsistence level of IFS was practised in all the ecosystems studies revealed that scientific interventions have resulted in higher productivity and resource conservation.

Kerala comes under the coastal ecosystem with an area of 1.18 % of the country and has about 3.2 % population resulting pressure on cultivable land. More than 90% of the farmers are having an area < 0.2 ha. By considering the agro-climatic conditions, the state is divided into 5 agro-climatic zones *viz*., southern, central, northern, high altitude and special zone for problem areas. The major crops grown are coconut, rubber, rice, pepper, banana/ plantain, arecanut, cassava, coffee and cashew. In the sixties, food crops occupied 30 % area of the total cultivated area of 2.918 m.ha while at present its area has been reduced to 12.25 %. The major farming systems in the State can be categorized as homestead based, coconut-based and rice-based systems.

Integrated farming system

Homestead based farming system

Homestead farming system is an age old production system. The traditional home- stead farming system in the state with its highly diverse crop and animal components has been a low input sustainable system evolved with nature, socio-economic, ecological and cultural aspects of the people. Homestead farming is the most common in IFS in Kerala and may be defined as an operational unit which is adjacent or surrounds the farmers home with a wide array of crops/trees with or without livestock and other subsidiary income generating activities for subsistence and for marketable surpluses. The major constraints in homestead farming is its complex entity which vary according to the taste of the farmers. It is a form of low input management subsistence model and since the situations within a small area differs considerably, models for different resource base is essential for homestead based IFS. Regeena *et al*. (2004) reported that based upon the biophysical and socio economic attributes the homesteads could be classified into five groups, *viz.* (i) homestead in upland with crops alone, (ii) homestead in uplands with crops and livestock, (ii) homestead in upland with crop, livestock and other subsidiary enterprises like apiary, floriculture, mushroom cultivation, fresh-water fish culture/ornamental fish rearing, (iv) homestead in upland with crop, livestock and agri-related cottage industries and (v) homestead with upland and adjoining wetlands for rice cultivation. Homesteads are thus a unit of polyculture of perennials, annuals and livestock for the nearly full exploitation of solar energy. It fulfills the strategies of agroforestry and is a rich source of biodiversity. A close scrutiny of features of homestead farming system of Kerala reveals that the system has several attributes of Globally Important Agricultural Heritage System.

Coconut-based farming system

Coconut is the most important crop of Kerala. It is cultivated as very small holdings to big plantations. Basically coconut is an integral component of most of the homesteads in Kerala. It is estimated by Nelliat and Krishnanji (1976) that being a mono-crop,it provided employment for only 150 man days/ha/year under rainfed conditions and consequently family labour remains unemployed for a large part of the year. Coconut-Based Farming System (CBFS) involving cultivation of compatible crops in the inter-space of coconut and integration with other enterprises like dairy, apiary etc offer considerable scope for increasing productivity and employment. The CBFS is an important farming practice among the small and marginal farmers to maximize land use, farm productivity and profitability. A number of researchers have confirmed the suitability of CBFS in coconut fields (Nair, 1979 and Bavappa, 1990). Perennial crops like coconut which occupy the land continuously for several decades, utilize the natural resources only to a limited extent producing <10 % of potential dry matter produced in the tropics (Nelliat *et al.*, 1974). Kushwah *et al.* (1973) reported that about 74% of roots produced by a palm under good management did not go beyond 2 m lateral distance and 82 % roots were confined to 31 to 120 cm depth of soil. The active root zone of the coconut is confined to 25 % of available land area. The coconut crown and orientation of leaves allow a part of light to transmit to the ground surface.

The nature and amount of sunlight transmitted through coconut canopy and falling on the ground shows temporal as well as spatial variation from planting to full development (8 years) and after 30 years, the light transmission is high and hence intercropping is possible. In CBFS, crops biological yield depends on the net assimilation rates under light wave length 400 to 700 nm. This is the photosynthetically active radiation (PAR) that penetrates coconut canopy. The crown of the coconut tree, particularly its morphology and palm height influence the available PAR for the under storey crops (cereals, root, fruits, pulses and fodder crops) which are identified for intercropping in coconut gardens and coconut based homesteads (KAU, 2007). Thus CBFS provides food security through food sufficiency and nutritional foods. Intercropped cereal as a source of carbohydrates, proteins and fats, root crops as source of carbohydrates and minerals, pulse crop as protein, fat and oils, fruit crop as vitamins and mineral, vegetable crop as vitamins, minerals, spice crops as food flavoring, vitamins and mineral and cocao as beverage are essential for food security.

The CBFS was defined by Magat (1990) as a system of practice in coconut production in which the available farm resources like coconut trees, soil and water/rainfall, farm labour, agricultural inputs and farm tools are utilized to produce nuts, food and non-food agricultural produce in a productive and profitable way. There are a number of factors and principles underlying the evolution of successful system. They include among other things, the shoot and root architecture of that plant species, their growth pattern, shade tolerance of crops, moisture availability, solar radiation spectrum, climate, social back ground of farmers and easy access to markets. These interacting factors keep the system in a dynamic stage till it reaches a stage of stability.

The CBFS are more sustainable for its efficient utilization of resources, *viz*. maximization of solar energy capture, optimization of soil moisture use and retention capacities, enhancement of soil fertility due to higher biomass generation over a period of time, minimal soil erosion and nutrient losses attributed to the effective and efficient crop canopies and root systems.

Nutrient cycling

In CBFS the produce, viz. nut and intercrop yield are usually exported out (removal from the farm). If the product is disposed as oil, the intermediate materials *viz.*, husk, coconut shell and water is available and can be recycled in the farm itself. The coconut husk, peduncle and fonds not used as fuel, can be recycled as organic source of nutrients. The amount of nutrients returned (kg/ha/year) to soil by recycling of different parts of coconut were estimated as 52-7-162 N-P-K in terms of fertilizers (Pandrones *et al.*, 1991)

In a high density multispecies cropping system study conducted at CPCRI, Kasaragod, it was clearly revealed that higher number of species diversity enhanced the nutrient recyling capacity. The contribution of each component crop, *viz.* coconut and intercrops to the nutrient pool is explicitly influenced by the nature of the species. The estimated annual nutrient recyling (Subramanian *et al.*, 2005) are presented in Table 1.

Coconut- based integrated farming systems

The coconut-based IFS studies conducted at CPCRI, Kasaragod and Kayamkulam revealed that the grass-legume fodder from coconut garden in the ratio of 3:1 (30 to 40 kg) could support 4 milch cows/ha. The total out put from 1.04 ha IFS model in 1994-95 was 19,125 nuts, 9,275 liter milk, 526 kg poultry, 50 Japanese quail bird and 400 kg fish. The economic analysis revealed that the total variable cost for the system was Rs 1,59,939. The gross and net returns/annum from the system was Rs 2,07,169 and Rs.66,678 respectively (Reddy and Bidappa, 2000). The IFS with small farmers (0.2 ha and less) developed through linear programming comprising 43 enterprises and with a cropping intensity of 161 provides a cost benefit ratio of 1:2.5 (Jacob and Nair, 1998). The crop live-

Table 1. Estimated annual nutrient recycling from multi-species CBFS under two fertilizer levels (kg/ha) CPCRI Kasaragod, 1989-1999 (Subramanian *et al.*, 2005)

Component crops	Fertilizer Nutrients (kg/ha)					
	N		P		K	
	Control	Fertilized	Control	Fertilized	Control	Fertilized
Coconut	46.0	81.9	5.40	10.60	79.4	123.4
Clove	5.6	10.8	0.28	0.47	6.6	10.7
Banana	2.9	13.2	0.40	1.30	14.9	73.7
Pineapple	1.9	4.4	0.64	0.89	7.2	15.3
Total	56.4	110.3	6.70	13.50	108.1	225.1

Under fertilized condition > 100% increase in recycling of nutrient was accounted in the study.

stock components selected in the models interact synergistically to increase the productivity and generate higher net returns.

The nutrient interactions expected in an integrated CBFS are depicted in Fig. 1 (Jacob and Nair, 1999). Removal from the nutrient pool includes primarily uptake by the trees and crops which becomes either locked up in the vegetative parts (mainly in trees) or exported through harvest produce. Nutrient removal through harvested produce is compensated by nutrient input through manure, fertilizer, recycled-crop residues and tree nutrient cycling processes. The tree components by virtue of their deep roots intercept, absorb and recycle nutrients that would have been otherwise lost by leaching, thereby making nutrient cycle more closed. The dense canopy cover provided by tree/crops protect soil against the direct action of rain thus reducing surface runoff. A dynamic equilibrium can be expected with respect of organic matter and plant nutrients on the garden floor due to the continuous addition of leaf litter and its constant removal through decomposition.

Fig 1. The nutrient interactions to be investigated and quantified and nutrient flow model proposed to be developed for the Integrated Farming System

Rice-based integrated farming systems

Rice fields in the coastal area are typical wet land ecosystem with numerous significant ecological and economic functions that benefit the society. There is a continuous surge for diversified cropping primarily on economic considerations. Crop diversification is a practical means to increase crop output under different situations. It is intended to give wider choice in production in a given area to expand production related activities on various crops. The common practices of adding more crops to the existing system is referred as horizontal diversification which broadens the base of the system. This multiple cropping has helped to achieve production potential upto 30 t/ha/year with an increase in cropping intensity by 300 to 400% (Varughese *et al.,* 2007). Crop diversification is influenced by factors, *viz.* (i) resource related factors including irrigation, rainfall and soil fertility, (ii) technology related factors covering seed, fertilizer, storage, processing and marketing, (iii) house-hold related factors covering food and fodder self sufficiency requirement as well as investment capacity and (iv) institutional and infrastructure related factors. Farm size and tenancy arrangements, research extension and marketing systems and government regulatory policies also effects, the above. The cropping system in different agro-climatic zones has been adopted by the farmers after long experience based on suitability of soil, profitability, availability of market and water control (irrigation/drainage). Techniques, *viz.* relay cropping, intercropping, mixed cropping, minimum tillage, weed control and use of chemical inputs have helped not only in reducing cost of production but also its sustainability over a longer period. Scientific cropping systems can actually result in increased soil productivity by improving the physical, chemical and micro-biological properties of soil and increase soil fertility.

Rice ecosystems in Kerala

High rainfall coupled with undulating topography of Kerala generate different moisture regimes for crop growth resulting in a wide range of micro-environments. Given the combination of seasons, and toposequence, rice in Kerala is grown under a variety of agronomic conditions. Over the centuries peasants of Kerala evolved a rice culture which is in symphony with rigid but heterogeneous environmental conditions with respect to control of water (deficiency as well as excess). They have evolved varieties and systems of rice culture to suit every conceivable agronomic condition from totally dry to floating rice under rising flood conditions, from rainfed to irrigated conditions, sandy to clayey soils and saline to acidic soils. Agronomic practices are tailored to specific environmental condition available in the area. The general rice-based cropping systems of Kerala (KAU, 2007) is presented in Table 2.

The studies conducted at Cropping Systems Research Centre, Karamana revealed that raising green manure (*dhaincha*), *bhindi* or short duration cassava in paddy fields during summer not only enhanced the profitability and employment but also resulted in a shift of the obnoxious weed flora *Echinochloa crusgalli* (Varughese *et al* ., 2007). In rice-based diversified cropping systems, the highest production potential and net income were obtained

Table 2. Rice-based cropping systems of Kerala (KAU, 2007)

General	Rice	Rice	Fallow
	Rice	Rice	Vegetable/pulse/oil seed/green manure
Kuttanad	Water fallow	Water fallow	Rice
	Rice	Rice	Water fallow rice
Onattukaraa	Rice	Rice	Oil seed/green manure
Kole/Kaippad	Water fallow	Rice	Water fallow
	Water fallow	Rice	Rice
	Water fallow	Water Fallow	Rice
Pokkali	Rice	Fish/Prawn	-
High ranges	Rice	Rice	Fallow

from one crop of rice followed by two crops of Neendran banana (Varughese, 2006). In such a cropping system (Table 3) with banana, over 10 t/ha crop residues were available for nutrient recycling. It also breaks weed spread and shifting of many problem weeds encountered in the wetland ecosystem.

Integrated farming involving aquaculture has great relevance to the coastal rice lands such as *Kuttanad, Kole* and *Pokkali/Kaippad*. In lowland rice the entire food chain and vast amount of fertile water can be fully utilized by integrating rice with fish. The rice-based farming system involving fish will not only reverse the present trend of non-utilization and under utilization of rice field but also make rice farming more attractive, consequent to the increase in productivity and profitability. As milch animals and poultry/duckery also form an integrated constituent of such a farming system, it can sustain food security. This system of farming could trigger a process of change whereby the income and economic prosperity of people living in these areas will increase leading to economic resurgence. Jayanthi *et al.* (2004), based on field experiments undertaken from 1998 to 2001 at Coimbatore on farming in lowlands reported that integration of cropping with fish, poultry, pigeon and goat resulted in higher productivity than cropping alone. Use of manures from the linked allied enterprises helped in increasing productivity of crops. Channabasavanna *et al.* (2000) observed from their integrated farm studies at Sirugappa that rice-fish poultry combination gave the highest net income with an improvement in soil health.

A study on testing and developing rice-based IFS for Kuttanad and such water fallow area was initiated in 1981 at the Kumarakam Centre of Kerala Agricultural University. In the laboratory model under on station trial for treatments, *viz.* (i) single crop rice and water fallow, (ii) rice and carps year round, (iii) double crop of rice and (iv) rice followed by fish were replicated. The fourth treatment of rice followed by fish was most promising and was tested as an on farm model (OFM) in the nearby polder of 8 ha in *Pazhayakayal*. Farming in this polder was taken up in a farmer participatory mode. This model was improved with constant modifications at multi-level integrated farming model involving rice and fish in low lands, pig, poultry and cattle along with coconut, banana and pineapple on dykes. During the lateral diffusion technology from OFM to polders in farmer managed trials (FMT), rice-fish integration alone was acceptable owing to its comparative advantages. A comparison of cost and returns of the diverse farming models were undertaken and micro-level study to quantify the economic and ecological advantages in two big farmers and a group of farmers are presented in Tables 4 and 5 (Padmakumar *et al.*, 2002).

In another study on economics of rice-fish farming system based on random sample of 200 farmers, 100 each from the traditional rice monocropping and rice integration with fish in Kuttanad revealed that the cost of cultivation for rice was reduced by 29% of which reduction in labour cost alone accounted for 20 %. The cost of production of rice/quintal was reduced through IFS with fish compared to mono-cropping of rice by 34% (Shanat, 2001). The rice based IFS studies conducted through the ECF scheme in Kerala have also indicated that in Kuttanad, the cost involved in dewatering and construction of outer bund were the major reason for the un-remunerative returns from rice cultivation. Mathew and Varughese (2007) in a case study on rice based IFS the major returns (79 %) were obtained from coconut-banana intercropping in the dykes and field bunds. The intervention of green manure,

Table 3. Effect of cropping systems on the rice productivity (rice equivalent) and economics for two year period (Varughese, 2006)

Treatments	Rice yield (t/ha)		Mean rice yield (t/ha/yr)	Mean yield of summer crop (t/ha)	Rice equivalent (t/ha/yr)	Net income (Rs/ha/yr)	B:C ratio
	Ist crop season	IInd crop season					
Rice-rice-fallow	4.51	3.59	8.09	-	8.09	12,167	1.27
Rice-rice-green manure (*dhaincha*)	4.76	3.74	8.50	14.58	9.54	20,801	1.41
Rice-rice-*bhindi*	4.63	3.95	8.58	13.38	14.35	32,434	1.38
*Rice-banana	4.64	-	1.16	24.01	28.61	77,108	1.35

*Rice only in the first year

Table 4. Changes in cost and returns and production in rice based Integrated Farming Systems models in Kuttanad (Padmakumar, *et al.* ,2002)

Year	Farming System	Rice variety	Yield (kg/ha)		Cost of production (Rs/ha)		Cost of production (Rs/q)		Net returns (Rs./ha)			Total return (Rs/ha)
			Rice	Fish	Rice	Fish	Rice	Fish	Rice	Fish	Others	
					On-station Research							
1983-86	Rice-fish-simultaneous	Cheru virippu	608-650	110-403	-	-	-	-	-	-	-	-
1986-87	Rice-fish-simultaneous	Pavizham	1,757-4,208	383-600	4,715	3,535	113	589	990	6,065	-	7,155
1987-88	Rice-fish-rotational	Pavizham	2,100-4,208	538-1,000	4,715	3,535	113	332	2,910	12,465	-	15,375
					On-Farm participatory Trial							
1996-97	Rice-fish-rotational	Jyothi	2,625	1,140	8,073	22,896	308	2,008	5,216	7,878	4419	17,513 *
1997-98	Rice-fish-rotational	Jyothi	3,219	1,289	10,211	20,966	317	1,627	6,091	12,234	5,732	24,057 **
					Farmer managed trials							
1995-96	Rice monocropping	Jyothi	2,338	-	12,013	-	517	-	859	-		859
1996-97	Rice-fish-rotational	Jyothi	3,563	347	10,925	3,350	307	965	8,716	6,453		15,169
1997-98	Rice-fish-rotational	Jyothi	4,105	673	11,780	11,403	287	1,694	13,350	8,460		21,810
1998-99	Rice-fish-rotational	Jyothi	4,178	1,643	8,563	21,683	205	1,320	17,915	18,610		36,525
1999-00	Rice-fish-rotational	Jyothi	3,988	1,265	10,463	21,995	262	1,739	15,090	13,270		28,360
2000-01	Rice-fish-rotational	Jyothi	4,058	815	9,638	14,823	238	1,819	17,443	7,898		25,341

* Includes net returns from rice, fish, pig and cattle; ** Includes net returns from rice, fish, pig, poultry and banana/pineapple.

Table 5. Rice-fish rotational farming incremental returns (Rs/ha) from fish at north Kuttanad (Padmakumar *et al.*, 2002)

Farm size and number of farmers	Seed cost	Other input	Labour	Other Management	Total cost	Gross income	Net income	Fish yield (kg/ha)
Single large farmer having 8.1 ha	3,120	5,509	6,785	3,224	18,638	33,125	14,487	1,145
Single big farmer having 3.8 ha	4,082	6,495	4,913	Nil	15,490	39,050	23,560	1,562
34 small farmers group having 21.8 ha	3,850	3,813	4,536	3,483	15,682	21,527	5,845	979

husk burial and vermicompost with banana pseudostem provided a major share of nutrient in the farm (Table 6).

Sustainability through IFS

The concept of sustainability in agriculture depends upon the integration of three main factors, viz. environmental health, economic profitability and social and economic equity. On any farm, four natural ecosystem processes, energy flow, water cycle, mineral cycles and ecosystem dynamics are at work (Sullivan, 2003). These four ecosystem processes function together, complimenting each other. Sustainable agriculture require a system approach (Feenstra *et at.*, 1997). System implies a set of inter-related practices organized into a functional entity. Farming system therefore designate a set of agricultural activities organized while preserving land productivity and environmental quality and maintaining a desired level of biological diversity and ecological stability. Sustainable agriculture in farming with efficient use of natural resources for increased productivity and production would result in improved farm income, maintenance of ecological balance, easy accessibility to food and social benefits and improved quality of life for farming communities. An agro-ecological approach is an appropriate method to understand the success of sustainable farming systems, and to identify ways to improve the productivity, profitability and resource use efficiency.

It is concluded that the productivity of major crops are either static or declining in many parts of the country owing to various reasons. To sustain food security the approach of IFS is positive and will conserve the resource base through efficient recyling of residues within the system. The IFS models developed on ecosystems and sub-systems can be fine tuned through farmer participatory trials with multilevel interventions of experts. The dessimination of such models will help in anchoring sustainability in agriculture.

Future thrusts

- Quantification of biomass production under Integrated Farming Systems and its overall efficiency in attaining sustainability.
- Identification of efficient cellulolytic microorganisms for recycling of crop residues.
- Impact of IFS on the accumulation of carbon and carbon sequestration.
- Development of indigenous technology know how (ITK) of IFS existing in the farming community and its scientific validation and popularization.
- Development of On Farm Research to identify and adopt technologies for solving site specific problems.

Table 6. Nutrient flow and economics of integrated farming systems in western part of Kuttanad ecosystem ha/yr of multiplication (Mathew and Varughese, 2007)

Components Crop component	Unit	Intervention	Major nutrient requirement (kg)			Nutrient contribution to the system (kg)			Economics of the system (x 10^3 Rs/ha)				
			N	P	K	N	P	K	Production/ Maintenance cost	Gross Income	Net Income	% of the Expenditure	% of Profit
Coconut cv. WCT	88 Nos	1. Green manuring 2. Husk burial	43.7	28.0	105	60.5	21.7	51.3	1.1	43.8	32.6	5.0	24.1
Banana cv. Nendran	1250 Nos	3. Vermicomposting from pseudo-stem of banana	237.5	143.8	3.75	120.0	32.0	144.0	75.0	150.0	75.0	35.0	55.3
Rice	1 ha.	4. Medium duration high-yielding varieting	90	45	45	-	-	-	30.0	30.3	0.3	14.0	00.1
Animal component duck farming cv Kakey campel	375 Nos.	5. Dropping used in composting				25	25	25	98.6	126.4	27.8	46.0	20.5

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