Promoting Coconut-Based Agro-Ecosystem and Efficient Product Utilisation for augmenting on-farm income, improving quality of environment and conserving natural resources[1]

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1. Introduction:

1.1. Integrated farming and efficient product utilisation in coconut-based agro-ecosystems

Coconut farmers in many parts of the world including Asia find it difficult to sustain their families' livelihoods from coconut income. They often face limited landholding, declining productivity and volatile coconut prices, resulting in poverty, food insecurity and a low nutritional status. To address this problem, a coconut-based integrated farming system is often viewed as a sustainable alternative farming system particularly on small and marginal lands. The common coconut-based integrated farming observed in the Asian countries are 1) livestock integration (cow, goat, poultry, duck, rabbit, pig, etc.), 2) agriculture/tree crops integration (multiple species crops, mixed crops sequential, fruit and timber yielding trees, etc.) and 3) integration of aquaculture (shrimp farming, fish farming, prawn culture, etc.). The economic well-being of a farmer depends not only on the quantity of food produced but also on the effective product and by-product utilization as well as the importance assigned to on-farm integration and waste utilisation.

In the Philippines, Sri Lanka, and Indonesia, farmers are practicing various types of coconut-based integrated farming and utilising products efficiently**.** However, in many countries including India these systems have been poorly understood and this may be due to lack of knowledge and skill, land tenure, farm sizes, availability of labour, household cash position, tools/equipment availability, product prices, input costs, technology,

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marketing costs, distribution channel preferences and so on. Reviewing the various constraints to the adoption of improved farming system, Mack (1991) and UNESCO (1979) found that grazing cattle under coconuts also requires the farmer to learn additional techniques associated with animal husbandry and pasture management. While technically feasible, the integration of ruminants with tree crops may not be socially acceptable (Chen, 1989; Ontolan, 1988; Shelton, 1991), may require labour resources, which the farmer wishes to use elsewhere (Beets, 1990; King, 1984), or require initial capital investment, which the farmer cannot afford (Jayawardana, 1988).

In developing countries particularly in India coconut is either grown as a monocrop or as major component in multiple cropping systems with or without livestock. However, there is no proper selection of species nor proper combination and management. As a result, the income derived is much below the potential and the holdings are exposed to the degrading effects of natural forces causing erosion, biodiversity depletion and deterioration of soil health. Further, some authors mentioned that continuous production of crops without external inputs reduces the ability of the soil resource base to both provide and retain nutrients which often results in the decline of soil productivity (Willett 1995; Craswell, 1998; Limpinuntana et al., 2001; Noble and Ruaysoongnern 2002). In addition, commercial farming systems are a threat to the environment through a loss of genetic diversity and the possible negative impacts of these systems and their associated inputs (Ashby, 2001).

Effective utilisation of products/byproducts obtained from coconut-based agro-ecosystem remains challenging to the Asian rural living. The increasing need to promote effective utilisation of farm-derived produce for value addition has been recognised not only because of the concentration of the population in rural centres but also because of other factors including the emergence of newer technologies and rising public awareness on the importance of waste utilisation. In a coconut-based agro-ecosystem, effective utilisation of product/by-product is depended on the types of products (from coconut, plant and animal, kitchen), processing scale (industrial or household scale), and objective of value added products preparation (for economic or energy). Throughout these steps, the main aim is to maximise conversion of waste into value added products without compromising environmental quality.

There is no doubt that all countries in South and Southeast Asia are effectively using and converting coconut farm products into energy and value added items. Simultaneously, a holistic approach becomes essential for increasing raw material

availability and evolving efficient processing and marketing strategies in rural areas to empower women. The essential requirements in these directions are production increase at farm level, linking farmers to the market, organic management of coconut farming, adherence to international quality, farm level and community level possessing, market promotion, and encouragement in coconut-based ecotourism.

1.2 Strategies for improving coconut-based agro-ecosystem and biomass waste utilisation in Kerala, India

India is the third largest producer of coconut in the world with a share of 15.9% in area and 25.4% in production. Although the area under coconut in Kerala increased from 0.66 million ha in 1981-82 to 1.02 million ha in 1997-98, thereafter it started declining and currently it occupies only 0.90 million ha, accounting for 40% of the total area under coconut in the country (Thampan and Vasu, 2007, CDB, 2002). The main factors responsible for the decrease in area and production are the spread of mite infestation, debilitating root wilt disease, intermittent drought and inability of the coconut farmers to develop necessary irrigation infrastructure due to the small and fragmented nature of holdings, soil nutrient depletion, market fluctuation, and lack of community participation.

The constraints faced by the coconut farmers call for bold and imaginative changes in the methodology of programme implementation so as to achieve the desired impact at the field level. To achieve this, the Government of India established the Coconut Development Board during 1981 (Dhanuraj, 2004) and introduced schemes/projects to promote coconut agro-ecosystem and biomass waste utilisation. The Board's Programs are either implemented directly or through the Departments of Agriculture and Cooperation of the States. Financial institutions have also formulated coconut financing schemes in potential areas both for fresh coconut planting and intensive cultivation. Integrated coconut development schemes with farm infrastructure facilities, such as wells, pump sets, fencing, and drip irrigation systems, have also been considered.

The Board is also making efforts through a cluster approach, replanting and rejuvenation, irrigation and moisture conservation, quality enforcement in planting material production, primary processing, consumer education, promotion of community participation and leadership at local level for stimulating community action in the sphere of ecologically sustainable farming system, marketing and operating micro credit for the benefit of the farmer members.

2. Overview of Pattanakkad Block of Alappuzha District, Kerala

The geographical location of mandated study region is broadly shown in the Kerala map (**Fig. 1**) and lies between 9° 5' north latitude, 76° 17' and 76° 44' east longitude. Pattanakkad block comprises 8 panchayats falling within Cherthala Taluka of Alappuzha District. The block has an area of 107.74 sq.km with a population of 208,732 and population density of 1,937, with women numbering 105,884 or 50.72% (Kerala State Environment Report, 2007). The area under coconut is 6,866 ha with over 1.7 million coconut palms (Mahesh, 2000). Small and marginal farmers with average land holding size below 0.5 ha dominate the coconut sector. Coconut-based activities particularly coir spinning constitute the major source of livelihood for over 60% of the households. Over 80% of these households fall below the poverty line. Apart from coconut-based activities, fish processing is a significant source of income and employment for a sizable number of women belonging to the socially and economically weaker families. The average household income of over 60% of the families in the project area is below USD 400 per annum and, hence, they fall below the poverty line.

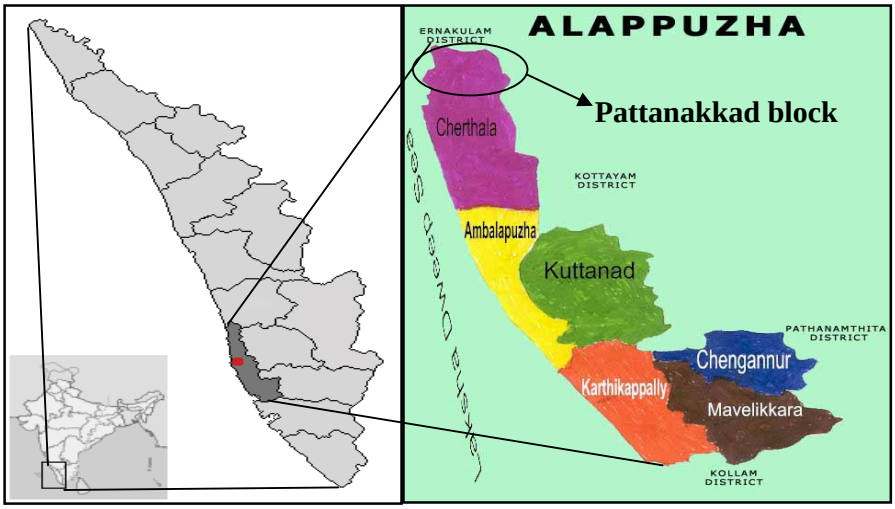

Fig. 1 Study area map showing in Kerala state, India.

2.1 Scope and strategy adopted by Peekay Tree Crops Development Foundation (PTCDF) to improve coconut based agro ecosystem and biomass waste utilisation

In most of the coconut holdings in the project site the available land area is devoid of species diversity (plant and animal) with the result that the income derived is much below the potential. Because of inadequate surface cover of diverse plant species and

absence of livestock integration, these holdings are also exposed to the degrading effects of natural forces causing biodiversity loss, soil health deterioration and declining food security and nutrition. These situations cause higher incidence of devastating pest and diseases and a steady decline in the productivity of coconut, which threatens the livelihood security of the dependent farm households.

In coir processing, dominated by resource-poor women, the traditional processing method presently being followed causes health problems to the workers, as well as pollution of water bodies and atmosphere to the discomfort of the local community. Although the coir industry is the major source of income and employment for the local people, the processing of coconut husk for fiber and pith for compost production has not developed on a commercial scale in the project site. Consequently, coir fiber, the raw material for spinning into yarn, has to be supplied from external sources, the regularity of which often gets disrupt causing insecurity of income and employment of the workers in the spinning sector. Eco-friendly coir pith management is another challenging aspect in project area. The potential of coconut wood as a construction material in lieu of hardwood trees is slowly gaining acceptance. Few coconut wood processing units are presently functioning in the block.

With a literacy rate of 93%, the people are responsive to innovation in the production sector and are conscious of the importance of adopting such practices that are conducive to the growth of the community without impairing the quality of environment. The conservation and efficient utilisation of the locally available organic sources of nutrients has not yet become popular among the farmers. This has resulted in the wastage of potential plant nutrient sources and atmospheric pollution. Similarly coconut farmers have not been exposed to the concept and practice of green farming for wider adoption as a viable and sustainable farming system.

To address these issues Peekay Tree Crops Development Foundation (PTCDF) initiated a project entitled *"Promoting Coconut-Based Agro-Ecosystem and Efficient Product Utilization for Augmenting On-Farm Income, Improving Quality of Environment and Conserving Natural Resources"* in Pattanakkad block during 2004-2009, which was funded by UNDP-GEF-SGP. To achieve the project objectives, PTCDF, as the project implementing agency, has adopted appropriate strategies comprising multiple species cropping in coconut holdings with medicinal plants and arable crops, livestock integration in the farming system, eco-friendly coconut biomass waste utilisation, supplying

improved tools and equipments, capacity building and women empowerment through participatory approach.

3. Research Objectives

This research was undertaken to identify the successful strategies adopted by the project implementing agency in promoting coconut based agro-ecosystem and efficient product utilisation for augmenting on-farm income, improving quality of environment and conserving natural resources. This case study also assessed the benefits of people's participation and a capacity building programme on off-farm income. People's perception on the efficiency and effectiveness of implementing this project was also assessed in this study.

4. Methodology

Generating adequate data on integration, waste utilisation and socio-economical items of the block before the treatment is the crucial component of any impact evaluation. Since sufficient benchmark data was not available before implementing the project in respect to Pattanakkad block, it was decided to adopt a participatory approach of data and information collection.

The information was generated based on observations during the field visits, observations monitored during and after the project, sample surveys and discussions with different stakeholders in the project area including individual households, farm clubs, charitable society, coconut product processing units and staff of the project. Random sampling was adopted for different items and components. Four villages, Aroor, Vayalar, Pattanakkad and Kodamthuruth were selected for the survey to represent south and north eastern radius of the Pattanakkad Block. Socio-economic benefits such as livelihood and income generation from the current farming practices and biomass utilisation were also explored. Finally, the impact of participatory approach and capacity building to empower women in the community and project sustainability was assessed.

5. Findings

The survey conducted in four villages namely Aroor, Vayalar, Pattanakkad and Kodamthuruth of Pattanakkad Block, Kerala presents the findings on integrated farming

practices such as growing of tree species of medicinal importance and arable crops, livestock maintenance and waste biomass utilisation at both household and community levels.

5.1 Promoting integrated ecological farming system

To create multiple sources of food, income and employment from each holding under coconut, Peekay Tree Crops Development Foundation successfully demonstrated an integrated ecological farming system in small and marginal landholdings covering 395 ha which benefited a total of 2,150 households (PTCDF, 2009). **Fig. 2** demonstrates an integrated coconut farm model.

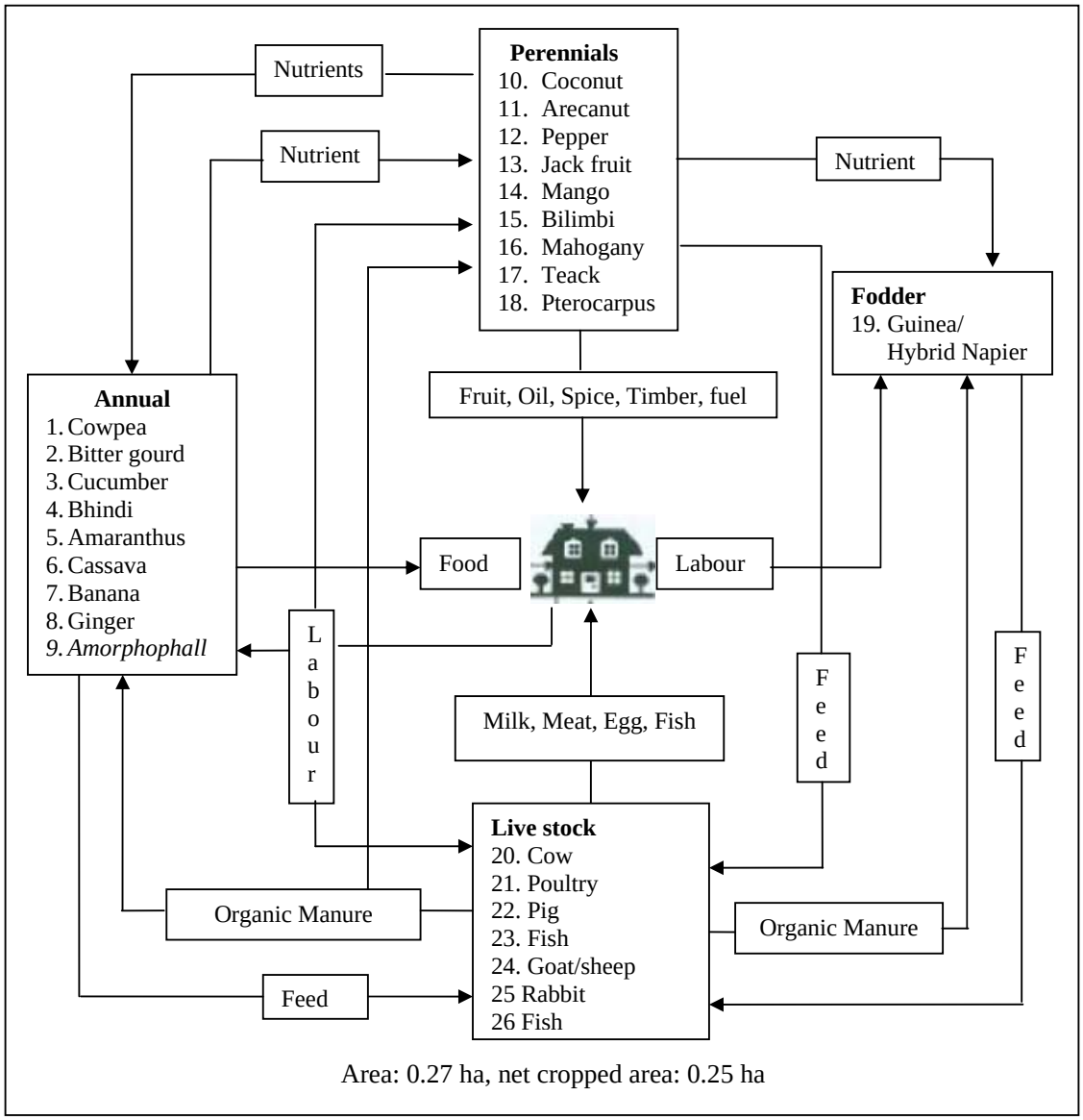

Fig 2. A model of integrated coconut based farming system (Thampan and Vasu, 2007)

All farmers in the study area possess small holdings ranging in area from 0.01 to 0.4 ha. During field visits we found that farmers adopted various combinations of the integrated farming system **(Fig. 3 and Table 1)**. Example of plant and animal species found in the project area are listed in **Table 2**.

Table 1 Overview of ecological integrated farming system in Pattanakkad block

Items	**Progress report PIA, 2009**		**Field observation from sampled survey, 2010**
	Before Project	**After Project**	
Average land holding (ha)	0.01 to 0.4	0.01 to 0.4	0.01 to 0.2
Number of Households benefited	None	1,500 + 650	100% family benefited from integrated farming
Type of Integration	Only coconut	Coconut with multiple tree species, vegetables, ornamental plants, animal, bird, fishes	MSC-rabbits-fish-bird farming MSC-cow farming, MSC-duck farming, MSC-duck-chicken farming, MSC-duck-chicken-goat farming
Average household income (USD/ha/yr)	<400	658	600-700
Other outcome	- Scarcity in food medicine, biodiversity loss, - Soil has low water holding capacity, low nutrient availability - Energy crises	- Increased biodiversity and food security - 2,329 tons carbon stock through plant biomass - About 173 ton carbon sink in the soil	- Increased in species diversity, composition - Increased in food security - Increased in soil moisture content and nutrients through mulching and biomass degradation - Increased in family nutritional status - Revitalization of local Ayurvedic medical system - Increased in family income and employment opportunity - Increased in energy security

Note : MSC referred to multiple species crops

: Ayurvedic medical system is a traditional medicinal system of Kerala.

Fig. 3 Integrated coconut farming found in Kerala

Table 2 Examples of diversification in integrated coconut farm in Kerala

Items	**Species name/common name**
Multiple species cropping (MSC)	*Acacia catechu Aegle marmelos, Cesalpina sappan, Garcinia camogia, Gmelina arborea, Melia dubia, Myristica fragrans, Phyllanthus emblica,Pongamia pinnata, Pterocarpus marsupium, Punica granatum, Strychnos nuxvomica, Tamarindus indica,Terminalia arjuna,Terminalia belerica, Terminalia chebula, Bannana, Coco, Turmeric, Ginger, Anthem Graveolens*
Animal	goat, cow, rabbit
Poultry	Chicken, duck, bird
Aquaculture	*Tilapia nilotica,Poecilia reticulate, Carassius auratus, Pterophyllum scalare,* etc.

Fig. 4 indicates that all farmers participated and benefited more or less equally by adopting different combinations of integration. From the field observations it was also noticed that the introduction of different combinations of integrated farming systems has

helped in conserving soil moisture, improving the quality of local environment and strengthening on-farm biodiversity. Introducing livestock and aquaculture in farmland brought tremendous improvement to the household food and nutrition security as well as income.

Apart from the ecological advantages it was also noticed that introduction of a variety of crops, animals, poultries and aquaculture into the coconut farm has increased the net household income from USD 400 to USD 600-700 per ha per year, besides freeing coconut farmers from the risk involved in the cultivation of monoculture. Promoting the cultivation of medicinally important tree species along with cash crops on a coconut farm helps in creating a dependable supply source of raw material for the Ayurvedic medical system, and generating organic waste and biomass for fuel thereby helping to increase the availability of per capita energy consumption.

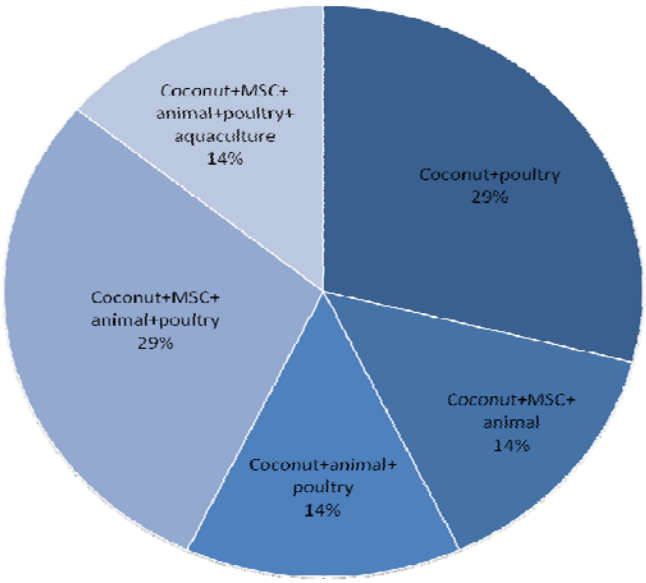

Fig. 4 Different types of integrated farming practiced by individual farmers in the study area (Source: From Field survey, 2010)

Apart from general observations, we also tried to analyse the contribution of each component to the increase in household income. **Table 3** describes that fish culture and chicken and duck-raising were contributing an equal share of about USD 22 per month, followed by cow-raising and multispecies cropping. The contribution from rabbit-rearing was found to be the least at about USD 3 per month. In the study area, all households use

products and by-products obtained from the different components as food, medicine, manure, firewood and biogas.

Table 3 Contribution of each integrated component to the household consumption and income

Particulars	**Area or Average Number per household**	**Products**	**Utilization**	
			Household consumption: food/manure/mulching/ medicine/energy	**Sell (USD/month)**
MSC	0.1 ha	Fruits, nuts, leaf, tubers	Yes	11
Rabbit	10	Leisure, meat, excreta	Yes	3
Fish	200	Leisure, meat, bone	Yes	22
Poultry	15	Egg, meat	Yes	22
Duck	20	Egg, meat	Yes	22
Cow	2	Milk, dung	Yes	13

Sources: From household survey, 2010

5.2 Natural resources conservation

We made a number of household visits in the Pattanakkad region and collected information on soil and water conservation practices adopted by the individual farmers. Integrating multiple species crops and livestock components not only increases the farm biodiversity and income, but also helps in soil and water conservation. In the study region, we found mainly two types of soil and water conservation practices (**Table 4**, ***Figs. 5 and 6***); namely agronomic (A) and engineering (E). A total of 86% of households were found to be practicing the agronomic methods of conservation whereas only 14% households were seen adopting the engineering. Common agronomic practices found in this region are intercropping, cover cropping and mulching. In the engineering practices, we found farm ponds and rainwater harvesting structures.

Table 4 Soil and water conservation practices found in Kerala

Type of practice	Examples	Plant Species
Agronomic (A)	Mixed cropping (MC), Mulching (M), Cover cropping (CP) Combination (MC+M), (MC+CP), (M+ CP), (MC+M+CP)	Brinjal, bitter gourd, green chilli, drumstick, yam elephant, Tulasi, Mango, Jack fruit, Banana, Papaya, Turmeric
Engineering (E)	Farm ponds, rainwater harvesting, drip irrigation	
Combined measure	Both (A+E)	

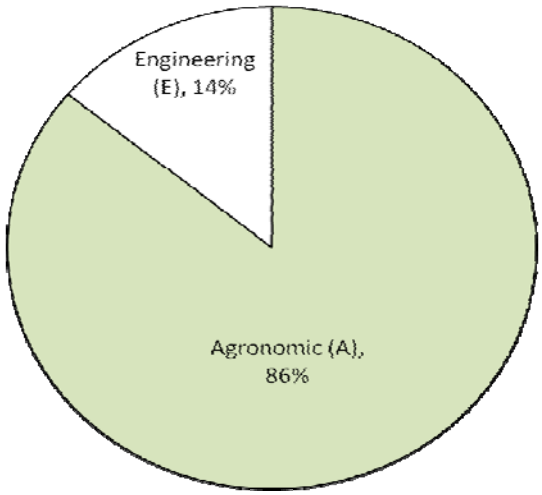

Fig. 5 Soil and water conservation practices adopted by individual households (Source: From household survey, 2010)

Fig. 6 Soil and water conservation measures found in Kerala

5.3 Biomass waste utilisation

5.3.1 Coconut husk and coir pith

Coconut husk is one of the important by-products of coconut-based activities. Coir spinning constitutes the major source of livelihood for over 60% of the households in Pattanakkad block. One fully mechanised coir fibre mill known as 'Vayalar Fibre Mills' with a capacity to crush 750,000 coconut husks per month was established under the aegis of a 10-member self-help group comprising eight men and two women. Over 2,500 households benefit economically from the regular supply of husk. The output of fiber husks is about 52.5 tons, which satisfies the daily raw material requirement of 58 households, providing fulltime employment for 116 women and part-time employment for 56 men members. Through the introduction of improved coir spinning wheels in place of the traditional ones, women have benefited from gainful employment and 50% higher income than what they were earning previously (from USD 1.0 to USD 2.5 per day). One mat and matting unit and another geo-textile unit are presently linked with this fibre mill. Currently, the products produced from this fiber mill are coir yarn, coir matting, carpets, geo-textiles, and nursery media (**Fig. 7a-c, Table 5**).

(a) Coconut husk processing

(b) Coconut fibre yarn spinning

(b) Coconut fiber for nursery media

(d) Composting from coir pitch

Fig. 7 Coconut husk utilisation: yarn, cultivation media, compost

Another eco-friendly activity at the project site promoted by Peekay Tree Crops Development Foundation is coir pith composting (**Fig. 7d**). Coir pith is a by-product obtained during the extraction of coir fibre, which gets accumulated, and causes water and air pollution. To obviate this problem, a green technology for coir pith composting was promoted through formation of a self-help group. Every month, around 105 tons of coir pith becomes available for composting. The present production of organically rich coir pith compost is about 5.6 tons/month. This compost consists of rich nutrients and is used as a soil conditioner, surface mulch or rooting medium. About 11 families are benefiting and their monthly income is approximately USD 826.

Table 5 Coconut husk management and household benefits in Vayalar village of Pattanakkad Block, Kerala

No	**Particulars**	**Source of information**	
		PTCDF, 2009	**Observed, 2010**
1.	Products	Coir yarn, matting, carpets, geo-textiles, coir pith manure	Coir yarn, matting, carpets, geo-textiles, coir pith manure
2	Production (tons/month) Fibre Coir pith	 52.5 105	 52.5 105
4	Number of households Benefited Direct Employment Indirect Employment	 134 2,500	 134 2,500
5	Economic improvement (USD/person/day)	1	2.5
6	Organic waste utilisation Compost production (ton/month) Number of family benefited Income from selling compost (USD/month)	Coir pith composting 2.1 11 331	Coir pith composting, mulching 5.6 11 826

5.3.2 Coconut wood and shell

Coconut wood has been proven to be a good substitute for many conventional woods. Like conventional wood, the coconut stem is durable, sturdy and versatile. Coconut wood can often be used at a considerably lower cost. To understand the current scenario of coconut wood utilisation in this region, we visited 'Jupiter Production cum Training Centre for Coconut based Handicrafts' located at Vayalar village of Pattanakkad Block (**Fig. 8**). This is a production cum training unit where coconut wood is being

effectively used to prepare building material, interior decorative, wooden floor, furniture, kitchen utensils, handicrafts and wooden planks.

The availability of raw material is plentiful and usually collected from the surrounding area (5 km radius). Preferred coconut wood is 40 to 100 year old trees with straight bole, disease- free, and either dead or alive. Wood seasoning is one of the important steps to make wood for long durability. They follow the water soaking method for 48 hours, using a mixture water of 5% copper sulfate (5%) and 5% potassium dichromate.

Fig. 8 Coconut wood manufacturing and products from coconut's wood

This centre is also responsible for creating direct employment opportunities to 11 families, out of which 50% are economically poor women. Currently, these families could earn almost USD 200 per month. Apart from this about 15 to 25 families are enjoying part time employment in their homes, and hence support livelihood improvement. The firm also follows industrial safety measures like providing masks, medical kits, and regular medication to the labourers.

The centre adopted a cost-free marketing strategy through personal contacts, friends, spread by the word of mouth and so on. By doing this they captured good markets in the local area, as well as in the neighbouring states like Karnataka and Tamil Nadu, to sell their products. Every month the centre could sell products valued at USD 4,445 and out of this, there is a 20% net profit.

5.3.3 Non-coconut waste

Apart from the ecological advantages it was also noticed that the introduction of multiple species crops and livestock component in coconut farmlands increases the non-coconut waste biomass which boosts energy security and soil nutrient status along with extra income to poor families. Commonly observed non-coconut waste biomass are plant

and animal residues like green manure, branches, dry leaves, twigs, cow dung, urine and excreta, residues of mushroom media, and kitchen waste. In the study area, a majority of the households convert this non-coconut biomass waste to organic manure or energy for households and to earn extra income for the family (**Fig. 9**).

(a) Rabbit excreta for fertilizer

(b) Rabbit excreta, kitchen waste and other farm waste for biogas generation

Fig. 9 Examples of non-coconut biomass waste utilisation in Kerala

Table 6 indicates that a single composting unit using residue of mushroom media can yield up to 12-18 kg/month and the income generated from each unit is about USD 2.5 per month. We also visited two vermin-composting units and analysed that the vermin-compost produced from these two units was 16-20 kg/month and extra income raised about USD 4.5 per month.

The biogas units are playing an important role in household energy security and cost saving. Every month the unit could produce about 60 cubic meters of biogas which fulfills one-month energy need. Discharge from the biogas unit is effectively utilised as liquid fertilizer.

Table 6 Type of products, yield and income generated from non-coconut waste

Particulars	**No of units**	**Yield (per month)**	**Income or saving (per month)**	**Raw material used**
Mushroom media composting	1	12-18 kg	USD 2.5	Mushroom media,
Vermin compost	2	16-20 kg	USD 4.5	Kitchen waste, green manure, livestock waste
Biogas	1	60 cubic meter	USD 15	Kitchen waste, rabbit excreta, cow dung

(Source: from field survey, 2010)

5.4 People's participation and capacity building

To make this programme successful and sustainable, Peekay Tree Crops Development Foundation adopted a strategy involving people's participation and a capacity building programme through the promotion of self-help groups, farm clubs and a charitable society at the project site. To impart knowledge, share information and technology and also to empower rural poor women, one permanent training centre 'Rural Technology Training Centre (RTTC)' has been established under the project for the benefit of potential rural entrepreneurs. Approximately 40 series of skill development training, workshops and seminars were organised in the area of agriculture production, animal raising, product processing and marketing, waste management, articles of decorative value and so on (**Table 7**).

Table 7 List of trainings conducted by Rural Technology Training Centre

No	Type of training	No	Type of training
1	Mushroom cultivation	20	Fashion designer
2	Food processing	21	Perfume production
3	Coconut based confections, savories, beverages etc	22	Office stationery
4	Coconut wood processing	23	Photoshop
5	Coir fibre based handicraft	24	Glass painting
6	Coir geo-textile	25	Knitting
7	Biological control of pest and diseases	26	Milk products
8	Paper carry bag making	27	Bakery products
9	Rabbit raring	28	Embroidery
10	Ornamental fish culturing	29	Fabric painting
11	Aquarium construction	30	Artificial jewelry production
12	Soft toys production	31	Cotton carry bag
13	Gardening and maintenance	32	Bee keeping
14	Floral arrangement	33	Decorated candle production
15	Interior designer	34	Vegetable seed production
16	Vegetable carving	35	Computer literacy
17	Wood craft	36	Palm climbing and medicinal devise
18	Repair and maintenance of farm equipments	37	Soap and detergent production
19	Poultry and cattle rearing	38	Medicinal plant growing

Around 2,260 men and 1,475 women participated and benefited from the RTTC training programme. The resource persons for imparting trainings were drawn from local experts, for instance, Coir Research Institute, Coconut Board, State Agricultural

Department, Vegetable and Fruit Promotion Council, Veterinary Department, and Agricultural University. Apart from the capacity building programme, farmers and women were sent on exposure visits to research and extension sites. Some successful case studies are described as follows.

The Peekay Tree Crops Development Foundation promoted numbers of coconut processing units and provided technical trainings on coir fibre spinning and coir pith composting. Around 370 households benefited from the supply of improved coir spinning units and linked to Vayalar fibre mill. From coconut fibre, each person could prepare 20 kg of thread a day and their daily income rose from USD 1 to USD 2.5.

Mushrooms are another important product enjoying market demand in the study area. Currently a self-help group consisting of 8 women members is running a unit called "Coon Fresh Mushroom" which has proved to be a profitable business. This unit consists of about 200-300 mushroom beds and the production is about 0.2 ton per 45 days (one batch). Currently there are 7 local varieties of mushrooms; namely cone 1, cone 2, Florida, solgerjan, pink variety and milky cone, and button mushroom. The mother spawns are purchased from Kumarkom Agriculture Research Center, Kottayam. Apart from production, various value added products like pickles, cutlets, ready mix soup, chutney powder, mushroom rasayanam, lehyam (ayruvedic jam) are being prepared at home. The demand for these value added products is very high. By maintaining this unit, the self-help group is earning a profit of about USD 1500 per 45 days or approximately USD 4 per person per day.

With the assistance of Peekay Tree Crops Development Foundation and the training provided by the Rural Technology Training Centre (RTTC), a 3-member women group started one catering unit. At present the unit prepares coconut food products and other articles enjoying market demand. Apart from this, the unit also supplies lunch and dinner for functions and marriage parties. The unit is running an equal share business and the profit is about USD 445 per month or around USD 5 per person per day.

A farmers' club called "Haritha Samrudhi" consisting of 14 members is actively involved in production of seedlings, supply of quality seeds, organic vegetable cultivation, marketing and competition. The group produced about 3,500 seedlings of medicinally important tree species and supplied to 300 families. Apart from these activities the group also conducts on-farm trainings especially on vermin-composting, fish culture and coconut farming.

In association with Karunya Women's Charitable Society, off-farm income generating activities were introduced to benefit poor women in the project area. Some activities being implemented are tailoring, decorating, glass painting, embroidery, etc. This society also helps to run a children's day-care centre that enables mothers to work for cash.

The Project also created a platform to link and involve other institutions like Block Panchayat, Village Panchayat, Krishi Bhavan, Coir Industry, Government of Kerala, Coconut Development Board, Coir Board, Alappuzha Coir Cluster Development Society, Vayalar Farmer's Club, Vayalar Community Development Centre, and Forest Department for sustainable development in coconut based agro-ecosystem.

6. Discussion

Different combinations of multiple species cropping help to conserve soil moisture, improve quality of local environment and strengthen on-farm biodiversity. Simultaneously, promoting livestock like cow, goat, poultry, duck and aquaculture in farmland strengthens food security, household nutrition and income. Integration of multiple species cropping and livestock components in the project site has helped in raising overall household income from USD 400 to USD 600-700 per hectare and also augmented the supply source of raw material for the local Ayurvedic medical system. This shows that individual households are effectively utilising available land for biodiversity conservation and raising household income. This became possible because of the availability of wide space between coconut trees for integrating miscellaneous tree species and arable crops and livestock components. Also the plant and animal residues generating from each component act as barrier to loss of soil and moisture in surface run-off, facilitate nutrient addition and improve the microclimate. Similarly Lightfoot and Minnick (1991) reported that the integration of trees into these systems offers income security and ecological protection. Further, animals on a farm provide inputs to other enterprises and constitute a source of meat and milk, a means of savings, and a source of social status (Schierre et al, 2002; Little and Edwards 2003). Coconut canopies may cause a reduction in air temperatures (beneath the canopy) as well as in soil temperatures which may be important for better seedling survival, soil water relations and possibly rate of litter breakdown and nitrogen mineralisation. Also, air relative humidity will be higher and soil water availability for intercrops will be maintained at a higher level than in the

bare surface because of less evaporation from the soil and lower crop transpiration rates (Wilson and Ludlow, 1991; Wilson and Wild, 1991).

Individual households are very much concerned about soil and water resources and their conservation. **Fig. 5** depicts that most (86%) households adopted agronomic practices like mulching, intercropping and mixed cropping, etc. The remaining 14% households were seen practicing engineering methods like farm ponds, rainwater harvesting, field bunding and so on. The higher rate of adoption of agronomic practices may be due to the plentiful availability of plant biomass from the integrated cropping system.

Efficient utilisation of coconut waste biomass mainly depends on the availability of resources, technology and market demand for the prepared products. Coconut husk is one of the important by-products of coconut tree and 60% households in this region depend on coir spinning activity. Through the introduction of improved coir spinning wheels in place of the traditional ones, women have benefited from 50% higher income than what they were earning earlier. Apart from this, every month around 105 tons of coir pith becomes available for conversion into compost.

Similarly coconut wood and shell are being effectively converted into value added products like furniture, kitchen utensils, handicrafts and so on. This shows that people are highly dependent on the coconut based activity and effectively using coconut waste for augmenting household income and environment conservation. This may be due to higher resources availability in the area, introduction of improved technology like motorized spinning units, and favourable market demand for the various products.

Among the different substrates for vermin-composting, people have shown higher interest in plant biomass and other farm wastes than residues of mushroom media which is presently being utilised in the project area.

The presence of biogas units satisfies the demand for household energy use. It also indicates that people have gained knowledge on how to convert farm waste and kitchen waste into energy. This may be due to sufficient plant biomass and animal waste generated in the integrated farming system that really act as a raw material resource for composting and operating biogas units.

Added to this, the use of diverse plants and animals broadens possible sources of income generation. The generation of wastes and by-products from these entities are transferred between enterprises, thereby reducing the need for external inputs such as feeds and crop nutrients (Cavas, 1992; Little and Edwards, 2003).

Promoting self-help groups, farm clubs, charitable society and rural technology training centres created a platform for project sustainability. Capacity building programmes on agricultural production, animal raising, processing and marketing, waste management, creation of decorative articles and so on improved the knowledge and skill of project participants and their household income. Providing technical trainings especially in spinning, catering and mushroom production, embroidery and tailoring helps in women empowerment through an increase in their daily income.

The intervention increased the interest, knowledge and technical skills in production, processing, packaging, labelling and market promotion of products among various communities in Pattanakkad block. By building capacity and collective action, the intervention also increased household income and employment. Linkages were established with both government agencies and private enterprises (more than 10 partners in this particular project) in the production and marketing of coconut-based products. Raw materials were better utilised and converted into more valuable products. The intervention also increased local and national awareness on the importance of coconut as a multi-purpose crop (the “tree of life”) among farmers, governments and private sector. This may be due to effective participation of local community, higher interest created by PTCDF through formation of groups, clubs, training centers and charitable society and presence of higher literacy rate in the study block.

7. Conclusion and Recommendations

The UNDP-GEF-SGP project that was implemented in Pattanakkad Block, Cherthala Taluk, Alappuzha District, Kerala State by Peekay Tree Crops Development Foundation is successful in introducing integrated coconut farming for sustainable livelihood and environmental conservation. As a result, food, fire wood and biodiversity at the farm-household level have been increased. The individual farmers appear to have good awareness about the techno-economic benefits of multi-tier and multi-species cropping systems, agro-forestry, livelihood activities, and livestock development in coconut holdings. Mulching is a common practice in every household. This has contributed to improvement in soil moisture relations and soil fertility status. However, maintenance of farm ponds was found sparsely. In addition, there is marginal increase in the food, employment, and household income through animal-raising such as poultry, rabbit, duck, goat and cow. Furthermore, it was observed that every household has good knowledge on efficient waste utilisation.

Out of the total geographical area (10,774 ha), 395 ha was treated until 2009. During the evaluation process, PTCDF and farmers suggested that the cost of financial support per hectare should be increase to help community and individual treating each part of the land effectively. Community-based organisations such as self-help groups, farm clubs, trust and training centres have been the major strength of the project by way of developing them as cohesive units to take up development works independently. Training programmes organised for the project participants have made great impact on household income, meanwhile supplying of improved tools and equipments increased employment opportunity and work efficiency in coir pith composting, coir spinning, catering, mushroom cultivation, wood crafts and decorative. Marginally increased income level and expenditure pattern proportionate to increase in assets showed positive impact of the project on socio-economic indicators and the project also generated good awareness among the people in the project area.

It was observed that there was a strong participation of community in sharing knowledge, discussion, and adaptation to new technology. Additionally, the project develops strong linkages with all departments to integrate their development schemes with this project and actively involve them as partners for better convergence to ensure sustainability after the project end.

Although the project has made some changes, it lacks in maintaining data, records and scientific impact analysis. Benchmark data needs to be correlated with clear improvement and development at the end of the project implementation to assess the total socio-economic transformation and impact on ecosystems. Monitoring the data could have been also made as a built-in mechanism in the project for evaluation of the impact of various activities apart from routine project works.

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