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Participatory technology assessment and refinement for evolving *Climate–smart* adaptations in the management of coconut based farming systems under coastal sandy soil conditions of South Kerala, India

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ABSTRACT

Climate-smart adaptations evolved during the course of participatory demonstration and assessment of technologies for management of Coconut Based Farming Systems (CBFS) in the Southern coastal tracts of Kerala resulted in reducing crop loss due to climate vagaries, improvements in soil properties, identification of ideal crops and their varieties and income enhancement from coconut and intercrops. Pine apple was found to be the most ideal crop withstanding water logging, followed by fodder grass and Nendran variety of banana. Climate resilient refinements by farmers viz., modified method of husk burial for pine apple, advancement of planting time, planting of 4-5 months old suckers and earthing up with silt, green manure, coir pith compost and husk for banana, planting of short duration varieties and advancement of planting time for tuber crops were proved to be successful.

Key words : *Adaptation, Climate resilience, Coastal, Participatory, Assessment, Refinement, Coconut based farming system*

Introduction

Coastal ecosystem in India occupies an area of about 10.78 million hectares and the coastline is approximately 8,000 km in extent, which is dominated by sandy light textured soils. This ecosystem generally lags much behind the inland areas in terms of crop productivity, mainly because of unfavourable climate, poor soil and hydrological conditions (Ray *et al.*, 2014). Coastal sandy soil is the predominant soil type for growing coconut along the West and East coasts of India. Even though the weather conditions prevailing along the coasts are conducive for growing coconut, the productivity remains low due to physico-chemical properties of the soil. Agro techniques developed by CPCRI viz., moisture conservation practices using husk/ coir pith for growing different intercrops, alley cropping of glyricidia, green manuring with glyricidia loppings, basin management with leguminous crops, direct utilization of coconut wastes for soil moisture conservation measures, vermicomposting of coconut plantation wastes and recycling and micro irrigation were successful in the Northern coasts of Kerala (Subramanian *et al.*, 2009). Apart from the poor fertility status of the soil, water logging due to precipi-

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tation variation and salt water inundation were observed as major impediment to successful cultivation of coconut in the southern coastal tracts of Kerala. This peculiar situation in the tract made it difficult for the farmers to take up cultivation of many of the intercrops and adopt year-round cultivation. Climate change in coastal areas affecting agriculture are frequent flooding, inundation by sea water, intrusion of salt water, rise in water table and changes in biological processes (UNFCC, 2006). In some areas, climate change will manifest itself in clear ways consistently year after year (e.g. warmer average temperature), and farmers will adapt accordingly. In other areas, however, climate disruption may be more difficult to react to, such as when there are changes to the variability of rainfall (FAO, 2012). Ray *et al.* (2014) also reported that most of the coastal areas suffer from excess water in monsoon season with attendant problem of prolonged deep water submergence having adverse effect on crop growth. According to IPCC (2007c), reduction of crop yields due to crop damage and crop failure, water logging of soils due to increased rainfall and flooding, increased livestock disease and mortality and salinization of irrigation water can all be expected to affect the activities and productivity of smallholder farms.

To overcome this situation, adaptability of different crops and varieties as well as recommended technologies need to be assessed for their suitability to the southern coasts of Kerala and appropriate adaptations to be undertaken to reduce vulnerabilities due to climate change. According to FAO (2013), one of the main features of Climate Smart Agriculture (CSA) is identification of barriers to adoption and providing appropriate solutions. For CSA to become a reality an integrated approach responsive to specific local conditions is required. Increasing diversity of production at farm and landscape level is an important way to improve the resilience of agricultural systems (FAO, 2010; FAO-OECD, 2012; HLPE, 2012). However, it is also important to remember that most of the adaptation options presented are not only potential responses to climate change, but also practices or methods that affect other aspects of the farm production system which are influenced by conditions other than climate (Dolan *et al.,* 2001). Thus, in planning and selection of adaptation options, a systematic approach to evaluation of these options should be followed, keeping in mind potential effects on other farm activities and processes. With this background, ICAR-Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala, India laid out two Front Line Demonstrations in farmers' gardens in the southern coastal tracts of Kerala in the Agro Ecological Zone I- Arattupuzha (Alappuzha district) and Alappad (Kollam District) with the objective of identifying crops and varieties suitable for the Southern coastal tracts of Kerala and to demonstrate the agro-techniques developed by CPCRI for management of Coconut Based Farming Systems under coastal sandy soil conditions coupled with participatory assessment and refinement for climate resilience. Promoting, revitalizing and scaling up existing local and traditional knowledge of crop management and ecosystem services can effectively support adaptation to climate change by marginal rural and indigenous communities and strengthen the deployment of new technologies. (IFAD, 2012).

Methodology

Area of implementation

The programme was implemented in 0.6 Ha. area each in the Alappad Panchayat of Kollam District and Arattupuzha Panchayat of Alappuzha District of Kerala, India during 2012 - 2014.

Alappad coast is a narrow barrier island strip of width 250-500 m sandwiched between the sea and a canal called the *T.S. canal* and the demonstration area lies within this 500 m strip. The latitude of Alappad is 9° 42 43.883 N and longitude is 76° 292 29.693 E. Portions of the village were damaged during the 2004 Tsunami and Alappad was the worst-affected village in Kerala.

Arattupuzha Coast is the extension of the barrier island on the north of Alappad coast, which is separated from Alappad by the inlet to the Kayamkulam lagoon and has a width >500 m. The latitude and longitude of the area are 9° 132 39.723 N and 76° 252 28.643 E respectively.

Mode of implementation

Technology demonstration was undertaken in a participatory mode with timely assessment of the practices and suitable refinements for climate resilience. The steps followed include:

- Introducing recommended technology package to the farmers.
- Selection of Technology options from the recom-

mended technology package with farmer participation.

- Implementation of the selected technology options.
- Monitoring and evaluation of technologies coupled with analysis of vulnerability of small farmers to climate risks
- Farmer participatory identification of strategies and measures to enhance resilience of CBFS.
- Assessment of strengths and weaknesses of adaptation options.
- Identification of ways to further improve adaptive capacity based on experience and field testing for refinement.

Methods of technology transfer

Experiential learning through method demonstrations, Farmer Field Schools and household level trainings were arranged to improve the skill and efficiency of the farmers and for horizontal spread of technologies.

Major interventions

- Moisture conservation practices : Husk burial & Direct utilization of coconut and other crop wastes
- Application of microbe enriched coir pith compost
- Basin management with green manure cow pea & soil test based nutrient application for coconut
- Irrigation: Basin/Micro irrigation
- Intercropping
- Need-based plant protection operations

Screening of intercrops and varieties

The following intercrops and varieties were screened at Alappad and Arattupuzha by the farmers for their adaptability in terms of tolerance to water logging, growth and vigour and yield under the Southern coastal conditions:

1. Banana: 4 varieties – Njalipoovan, Nendran, Red Banana and Robusta
2. Pineapple : With husk burial (Sideways around the plant and at the bottom of the trenches of planting) and without husk burial. (var: Vazhakkulam)
3. Tuber crops:

- Elephant foot yam: Gajendra, Sree Padma and Peerumedu Local
- Dioscorea: Sree Dhanya, Sree Keerthi, Sree Karthika and Sree Shilpa
- Lesser Yam: Sreelatha
- Tapioca: Sree Jaya, Sree Vijaya and Vellayani Hraswa

4. Vegetables: Amaranthus, Bitter gourd, Salad cucumber and Cow pea, Cauliflower, Cabbage, Tomato

Fodder grass: CO-3

Spices: Ginger and turmeric

Recording of observations

Soil nutrient status before and after the demonstration was recorded using standard procedures outlined in Jackson (1976). Data on yield and pest and disease incidence were recorded in case of coconut and performance of intercrops were evaluated in terms of visual observations on growth and vigour, tolerance to water logging, yield particulars and pests and disease incidence. Performance of intercrops planted with and without husk burial / application of coir pith compost under coastal sandy conditions were evaluated.

Statistical tools

Statistical tools like mean, standard deviation and t-test were used for data analysis and interpretation.

Results

Improvement in soil parameters

In order to assess the soil characters at the demonstration sites, samples were collected from coconut basin as well as from the inter row spaces of inter crops at a depth of 0-30 cm during 2012 and 2014. The samples from coconut basin were collected at a distance of 1.5 meter from the trunk on either sides, which were composited and later air dried and sieved and analysed for soil reaction, organic carbon and available nutrients and are presented in Table 1.

At Alappad, soil reaction was moderately acidic, with low organic carbon and extremely low exchangeable calcium. Available potassium and magnesium were in the medium range. In the intercropped area, continuous crop exhaustion resulted in the reduced potassium status in the soil though soil test based nutrient application was practiced. In turn this was reflected in the enhanced yield specifically from pine apple. Application of lime resulted

Table 1. Improvement in soil parameters at Alappad and Arattupuzha

Soil parameters	Alappad				Arattupuzha			
	Coconut Basin		Intercropped area		Coconut Basin		Intercropped area	
	2012	2014	2012	2014	2012	2014	2012	2014
pH	4.50	6.05	5.20	5.45	6.34	6.75	5.37	6.10
E.C (dSm-1)	0.66	0.36	0.19	0.43	0.05	0.28	0.02	0.30
O.C (%)	0.39	0.68	0.41	0.54	0.15	0.24	0.23	0.38
K (ppm)	58.50	172.00	29.00	27.00	59.50	129.50	22.50	118
Ca (ppm)	37.50	72.50	62.50	80.30	397.30	413.50	250.50	285.50
Cu(ppm)	2.56	3.98	0.32	0.38	0.65	0.84	0.52	0.58
Mg (ppm)	105.00	152.80	108.80	128.60	52.20	62.80	100.00	71.60
P (ppm)	144.50	85.60	106.00	102.80	32.14	25.60	102.35	35.50
Fe (ppm)	291.70	138.50	339.70	172.60	129.10	92.63	328.00	258.6
Mn (ppm)	7.10	22.50	6.30	5.80	1.52	2.60	1.63	0.89
Zn (ppm)	6.80	1.20	1.50	2.30	0.77	0.32	0.50	0.95

in the improvement of soil reaction along with increase in the exchangeable calcium content. Adoption of management strategies especially crop residue recycling resulted in the improvement in organic carbon status to the tune of 74 per cent in the main crop and 32 per cent in the intercropped area.

Soil in Arattupuzha was found to be slightly acidic and non saline with low organic carbon content. Availability of potassium, magnesium and zinc was found to be extremely low whereas the availability of phosphorus and iron was on the higher side. Improvement in the soil properties after the adoption of suitable management strategies was observed. Application of need based amendments and fertilizers resulted in the improvement in the content of potassium, magnesium and calcium. A reduction in the content of iron and phosphorus was also observed. The trend in the soil fertility change was similar in both coconut as well as in the intercrop.

Improvement in the soil properties after interventions was reflected in the crop yield and other attributes. This implies that better management options considering the inherent soil fertility constraints can bring out qualitative improvement in soil attributes, thereby contributing to climate resilience. Increasing soil organic matter allows soil to capture and retain more water, which reduces the vulnerability of organic agriculture systems to climate extremes such as droughts and floods (Muller, 2009).

Table 2. Spread and intensity of rainfall during May-July (2012, 2013 and 2014)

2012			2013			2014		
No. of continuous rainy days	Mean daily rainfall (mm)	SE	No. of continuous rainy days	Mean daily rainfall (mm)	SE	No. of continuous rainy days	Mean daily rainfall (mm)	SE
4	73.48	50.80	5	10.14	2.96	3	10.07	4.51
2	1.25	0.55	35	26.00	3.94	6	34.05	18.35
6	3.48	1.97	6	23.02	11.21	2	1.7	0.9
5	12.00	5.78	20	23.39	4.28	3	4.0	1.89
6	14.58	4.31				4	2.65	1.20
3	1.37	0.43				11	23.69	6.29
4	10.18	3.76				7	8.03	1.96
3	28.57	17.62				8	6.69	3.65
9	13.20	4.02				9	14.37	3.93
5	7.30	3.06				10	8.89	2.68
92	8.87	2.67	92	17.35	2.20	92	10.55	1.92

Pattern of precipitation events during 2012-2014

Water logging is generally seen at Alappad and Arattupuzha during rainy season mainly due to high water table and low water holding capacity. Depth of water table in Alappad during monsoon season is 0.75m and 2.30m during pre-monsoon period (Suraj *et al.*, 2009). Mini (2009) also reported about the water logging seen in a limited area along the western border of Kollam district bordering the backwater lagoons during rainy season.

Extreme variation in the precipitation pattern in terms of both spread and intensity was observed during 2013, compared to 2012 and 2014.

Over a period of 92 days during May to July, there were 47, 66 and 63 rainy days with daily average rainfall of 8.87mm, 17.35mm and 10.55mm during 2012, 2013 and 2014 respectively. The table revealed two long spells of 35 and 20 days of continued rains with daily averages of 26 mm and 23 mm respectively during the year 2013, compared to that of 2012 and 2014. Weekly distribution of rainfall also revealed more spread with moderate intensities of rainfall during 2013, compared to 2012 and 2014 (Fig.1).

Continued rainfall with moderately higher intensities during 2013 resulted in prolonged water logging than that of 2012 and 2014. But crop loss was more during 2012 with normal management practices (Table 3), which was considerably reduced during 2013-14 due to adoption of various climate-resilient measures (Table 4).

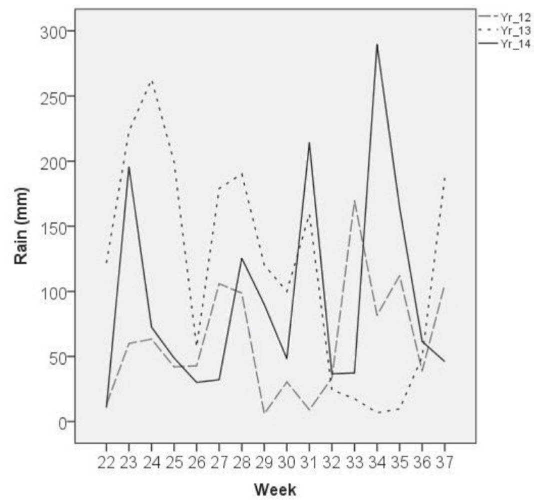

Fig. 1. Weekly distribution of rainfall during 22nd to 37th week (June to September)

Screening of crops (variety-wise) ideal for the coastal tract based on susceptibility / tolerance to water logging based on observation by farmers

Prolonged water logging during rainy season in the Southern coastal tracts made it difficult for the farmers to grow many of the crops successfully. Post-

Table 3. Variety-wise performance of different intercrops in the southern coastal tracts based on

Crop & Variety	Pre-monsoon	Post-monsoon	Yield		Crop loss
			Attribute	Range (kg)	(%)
PineappleVar. Vazhakkulam	Excellent	Excellent	Fruit	1.0 – 1.5	Nil
Banana					
Red Banana	Good	Poor	Bunch	6-16	90
Nendran	Very good	Very Good	-do-	5-8	18
Njalipoovan	Very good	Average	-do-	8-17	73
Robusta	Very Good	Average	-do-	7- 19	24
Tuber crops					
Elephant foot yam	Very Good	Average	Plant	4-7	18
Dioscorea	Very Good	Poor	-do-	2-5	54
Taro	Very Good	Good	-do-	1-3	60
Tania	Very Good	Very Good	-do-	1-2	25
Tapioca	Very Good		-do-		100
Fodder grass	Excellent	Excellent[1]	Fodder/m^2	12 - 15	
Spices			Plant		
Ginger	Good	Poor	-do-	-	90
Turmeric	Good	Poor	-do-	-	60

[1]Lanky growth during monsoon but recovered
susceptibility to water logging

monsoon vegetable cultivation was the only predominant practice in both Alappad and Arattupuzha before starting demonstration. However, the farmers were interested in trying different crops and varieties which can be grown during rainy season and fetch more income. Based on that, different varieties of various intercrops were planted by the demonstration farmers in their gardens in the normal time of planting during 2012 and performance was evaluated. IFAD (2011) identified exploration of the use of improved seed varieties that can withstand flooding, drought and salinity and scaling up sustainable land management practices to improve hydro-geologic functions, soil nutrient replenishment, habitat heterogeneity, floral and faunal diversity, moderation of microclimate and reduction in pest infestations and soil salinity as priority areas for promotion of technologies that reduce vulnerability of rural livelihoods.

The suitability of different crops based on their ability to tolerate water logging during monsoon season in terms of the crop stand – both before and after monsoon, crop loss due to water logging and yield reduction due to poor soil quality and leaching as well as the yield levels were evaluated during 2013 and results are presented in Table 3.

Based on the above observations made by farmers, pine apple was rated as the most ideal crop tolerating water logging, followed by fodder grass and banana variety Nendran. When the early bearing stage of Njalipoovan variety of banana does not coincide with long periods of water logging, the yield was found to be very good, even up to 17 Kg/ bunch. Robusta variety was found to be moderately tolerant to water logging with moderate yields. The variety Red banana was found to be highly susceptible to water logging and the farmers have decided to avoid Red banana for commercial cultivation after the first trial. Among tuber crops, Taro alone was found tolerating water logging and providing very good yield. Different precipitation patterns affect crop yield trends more than temperature variability does (Schneider *et al*., 2008).

Adaptations for climate resilience: Impact of practices adopted by farmers

Various crops and varieties responded differently to the recommended planting techniques and management practices due to climatic vagaries, mainly water logging in the Sothern coastal tracts of Kerala. According to IPCC (2007a), climate change may lead to an increase in both crop and livestock productivity in mid to high latitudes and a decrease in tropical and subtropical areas. Climate change is suspected of having already significantly impacted agriculture (Lobell *et al.,* 2011) and is expected to further impact directly and indirectly food production. Increase of mean temperature; changes in rain patterns; increased variability both in temperature and rain patterns; changes in water availability; the frequency and intensity of 'extreme events'; sea level rise and salinization; perturbations in ecosystems, all will have profound impacts on agriculture, forestry and fisheries (Gornall, 2010; IPCC, 2007; Beddington *et al*., 2012; HLPE, 2012; Thornton *et al.,* 2012). Over the next 20 years, most projections indicate that the most important impacts of climate change will be, and in some cases already are, increasing frequency and intensity of climate shocks, such as drought, flooding and extreme temperatures.

Several farm level *climate smart* adaptations were followed by the farmers to increase productivity and build resilience in the coastal tracts and the impact of such practices over normal planting were closely observed and recorded by the farmers (Table 4). Adaptation can significantly decrease the vulnerability of households and communities to climate

Table 5. Comparison of pineapple planting methods (mean ± SD)

Parameter	Alappad (N=54)			Arattupuzha (N=48)		
	Normal practice	Husk placement side-ways	t-statistic	Normal practice	Husk placement at bottom	t-statistic
No. of weeks for flowering	63.90±3.92	56.79±5.18	7.58**	63.83±4.07	64.48±4.54	0.78
No of leaves at flowering	48.73±5.23	50.21±4.25	1.78	39.22±3.90	41.98±2.41	4.42**
Fruit weight (g/fruit)	1049.79±285.53	1746.25±152.83	14.90**	970.93±302.05	1454.26±265.58	8.83**

**Significant at 1%

change, moderate potential damages and improve their capacity to cope with negative consequences (IPCC, 2001). However, it is also important to remember that most of the adaptation options presented are not only potential responses to climate change, but also practices or methods that affect other aspects of the farm production system which are influenced by conditions other than climate (Dolan *et al.,* 2001). Adaptation measures are likely to be less capital intensive and more amenable to small-scale interventions (UNFCC, 2006). When designing a CSA strategy one must consider that, at the micro (farmer) level, adaptation strategies encompass a wide range of activities that will need to be evaluated and prioritized (FAO, 2012). Examples include modifying planting times and switching to varie-ties resistant to heat and drought (Phiri and Saka, 2008); developing and adopting new cultivars (Eckhardt *et al.,* 2009); changing the farm portfolio of crops and livestock (Howden *et al.,* 2007); improving soil and water management, including conservation agriculture (Kurukulasuriya and Rosenthal, 2003); improving fertilizer use and increasing irrigation (Howden *et al.,* 2007); and increasing regional farm diversity (Reidsma and Ewert, 2008). Farming communities have considerable experience of coping with adverse climatic events, such as droughts and floods, and with salinity. They have, for example, introduced new forms of irrigation, or diversified to varieties that are higher yielding or have greater tolerance for drought or salty conditions (UNFCC, 2006). In the agriculture sector of Southeast Asia, some of the most commonly used adaptation techniques involve changes in cropping patterns and cropping calendar, improved farm management, and use of climate-resilient crop varieties (ADB 2009). The more important aspect of adaptation is the fitting of crops to their best use in the individual subplots of the farm. The demonstration farmers with their rich experience, tried several adaptation options viz., modified method of husk burial for pine apple, advancement of planting time, shifting crops from one area of the farm to another, planting of 4-5 months old suckers and earthing up with silt, green manure, coir pith compost and husk for banana, planting of short duration varieties and advancement of planting time for tuber crops to tide over the crop loss due to water logging, to improve soil characteristics and to ensure better yield; and paved a way in successfully refining the technologies to suit to the requirements of coastal farmers of South Kerala.

Pine apple was found to be the best crop, tolerating water logging and was planted with (i) placement of husk at the bottom of trenches (ii) placement of husk around the plant while planting and (iii) without husk placement (normal practice) and the impact was recorded (Table 5).

The results from Table 5 indicated that husk placement sideways around the plant at Alappad resulted in better growth and vigour, early flowering and higher fruit weight (1.75 Kg/fruit), compared to that of control (1 Kg/fruit). Majority of the plants (80%) planted with sideways placement of husk flowered during 50-60 weeks (average 57 weeks) without flower induction, whereas those plants in control were treated with Ethrel for flower induction during 57th week and flowering was com-

Table 6. Yield of coconut and economics of CBFS under southern coastal tracts of Kerala

Components of economic analysis	Alappad		Arattupuzha	
	2012-13	2013-14	2012-13	2013-14
Coconut yield (nuts/palms)	31	48	29	46
Increase in yield over pre-intervention (%)	-	55	-	59
Cost of cultivation (Rs./ha)				
Coconut	19,600	43,400	23,500	49,400
Intercrops	51, 200	51,600	48, 500	65,800
Total	70,800	1,01,000	72,000	1,09,200
Income (Rs./ha)				
Coconut	23, 580	51,300	44,400	79,400
Intercrops	88,700	1,26,400	95,975	2,18,800
Total	1, 12,280	2,36,000	1,40,375	2,98,200
Net Profit (Rs./ha)	41,480	1,35,000	68,375	1,89,000
BCR	1.59	2.34	1.95	2.72

pleted within 6-8 weeks.

At Arattupuzha, Pineapple was planted with husk placement at the bottom of trenches, which resulted in higher growth and vigour in the early stages with higher yield (1.45 Kg/fruit) compared to that of control plants (0.97 Kg/fruit). Subramaniyan (2009) reported that husk and coir pith as amendments had significantly influenced fruit size and fruit weight and significantly differed from control plants. But earliness in flowering was not observed in this case and all plants with husk placement as well as control were subjected to flower induction during 57^{th} week of crop growth. Number of leaves at flowering was found significantly higher for plants with husk placement.

In spite of the management practices adopted at Alappad and Arattupuzha to address the specific soil constraints, yield and yield attributes in relation to pine apple was more at Alappad, which can mainly be attributed to the superiority of the climate smart option of husk placement sideways around the plant, compared to that at the bottom of the trenches. IFAD (2011) reported that conservation agriculture practices potentially have productivity, adaptation and mitigation benefits.

In case of banana, the variety Njalipoovan, even though found susceptible to water logging, farmers preferred to grow it due to the higher yield potential, demand, marketability and price of product after standardizing suitable adaptation measures. Planting of the same variety during normal planting time with and without husk burial resulted in lodging of majority (73%) of the plants and moderate reduction in yield levels due to poor finger formation. Farm level adaptations like advancement of planting time, planting of 4-5 months old suckers and application of silt and potash could help to tide over the situation by saving 100% of the plants from lodging and to enhance the yield by 80%. One of the key means for communities to adapt to the changing climate is to progressively adjust their cropping calendar so as to minimise the negative effects of changes in the timing of the rainy season (Sean, 2009). Further refinements during the next season of planting by adding green manure, coir pith compost and placement of husk while earthing up with silt along with the above adaptation measures further enhanced the yield levels by 44% (Table 4). Adaptation measures for Robusta variety as indicated in Table 4 resulted in saving of 90% of the plants from lodging and yield improvement to the tune of 57%.

Planting of tuber crops except Taro during normal planting time resulted in severe crop loss due to water logging. Adaptations like planting of short duration varieties of tapioca like Vellayani Hraswa (5-6 months), Sree Jaya (7 months), and Sree Vijaya (6-7 months) and advancement of planting time and shifting of planting areas in case of tapioca, elephant foot yam and dioscorea resulted in saving of the crops from water logging, improving yield and in ensuring higher price to the product during off-season. International research for adaptation to climate change also focuses on the search for a new generation of crop varieties. Another practice of retaining previous year's lost crop (elephant foot yam and dioscorea) in the field resulted in higher yield during off-season, enabling to obtain higher price thereby compensating the yield loss during previous year. In case of Taro, good yield was obtained from the coastal tract, in spite of the slight change in the crop stand during monsoon period. In case of Tania, tuber formation was reduced due to prolonged and heavy monsoon, for which the farmers applied 1 Kg coir pith compost along with 50g of Muriate of Potash while earthing up and yield was doubled. In case of vegetables, the better practice of planting with coir pith compost enriched with *Trichoderma sp.* along with other organics was found to ensure better growth and 20-30% improvement in yield.

Impact of interventions on coconut yield and income from Coconut Based Farming System

By taking up basin management, intercropping with fodder grass, vegetables, tuber crops, pine apple and banana and crop residue mulching together with plant protection operations, coconut productivity was increased. In addition to the extra income realized by intercropping, it has a complementary impact on coconut productivity and the overall system productivity (Subramanian *et al*., 2009). The yield of coconut and economics of the CBFS were worked out for the periods 2012-13 and 2013-14 and presented in Table 6.

Due to the time lag in income realization from intercrops like pine apple and banana and partial crop loss due to water logging, the net profit from CBFS during 2012-13 was only moderate. However, BCRs of 1.95 and 1.59 revealed feasibility of the CBFS under coastal conditions, which prompted the farmers to undertake and validate adaptation measures against climatic vagaries. Through intensive crop diversification and cost effective adaptation measures, profitability of the system could be enhanced as shown in Table 6.

The yield of coconut showed improvement up to 59% at Arattupuzha and 55% at Alappad during 2014, over that of 2012. The net income from the coconut based cropping system varied from Rs.1.35 – 1.89 lakh during 2013-14 depending on the intensity of intercrops cultivated, which is around threefold to that of 2012-13. Improvements in BCRs to the tune of 2.34 and 2.73 during 2013-14 over the BCRs of 1.59 and 1.95 during 2012-13 indicate the economic viability of the adaptation measures undertaken for improving the productivity of CBFS in both the areas. IPCC (2007b) also reported that recent studies showed a high confidence that there are viable adaptation options that can be implemented at low cost and/or with high benefit - cost ratios.

Conclusion

Poor fertility status of the soil, water logging due to precipitation variation and salt water inundation in the southern coastal tracts of Kerala made it difficult for the farmers to take up cultivation of many of the crops and adopt year-round cultivation. Further, climatic vulnerabilities lead to decreased productivity of the cropping system. Productivity improvements and climate resilient adaptations are crucial for saving agriculture in the tract and the reactive adaptation measures viz., modified method of husk burial for pine apple, advancement of planting time, planting of 4-5 months old suckers and earthing up with silt, green manure, coir pith compost and husk for banana, planting of short duration varieties and advancement of planting time for tuber crops undertaken by few farmers were proved to be successful and sustainable to suit to the requirements of small farmers of the Southern coastal areas of Kerala. Scaling up of adaptation strategies and technologies is further required to bridge the adaptation deficit at a regional level, for which a community based approach is most suitable. Climate change, though a global concern, effects mostly felt at regional level. As envisioned by Kiser (2008), "through community based adaptation, local people are encouraged to harness their own knowledge and skills which builds their self-reliance, drive and commitment to respond to the challenges brought by climate change".

The adaptation practices identified under this work can further be modified to reduce the vulnerabilities and can be replicated at a wider level by using Integrated Climate Risk Assessment Framework for Small Farmers (ICRAF) developed by Lasco *et al.* (2011). This may also contribute in the identification of future climate risks and to anticipate the adaptive strategies to be followed. Adaptation deficit analysis through a multi-stakeholder collaboration, participatory means of planning, implementation, monitoring and evaluation of sound climate adaptation practices as envisaged under this framework if undertaken at a regional level can lead to additional adaptation systems using the inputs of farmers and development workers.

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