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Carbon Sequestration through Crop Production– the Case of Areca Based Farming Systems in Western Ghats Region of Karnataka; India

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Abstract: *The study demonstrated the ecological benefit from areca based farming system interms of carbon sequestration from trees in the system including arecanut. The indirect use value derived from areca based farming system in western ghats was Rs.6,492per acre per year.The return they could realize for the service may be substantial if a proper pricing of carbon stock and payment mechanism is envisaged. Nonetheless, arecanut being a major commercial crop of the region, its economics has got direct bearing on the sustenance of ABFS as well as carbon sequestration capability of the same*

1. INTRODUCTION

Carbon dioxide (CO_2) is the most important anthropogenic Green House Gas (GHG) which is accumulating in the atmosphere in large quantities resulting in identifiable changes in the state of the climate that persists for an extended period of time [6]. Agriculture, from the climate change point, is the oldest negative intervention in the nature as crop lands were raised by converting forest / woodlands over the centuries. Unlike other forms of crop husbandry, cultivating plantation crops like coffee, pepper, cardamom, arecanut and cocoa is accompanied with the growing of tree species also, for shade, support, wind break, soil and water conservation purposes. The trees with in the plantations in turn act as carbon sink to mitigate the ill effects of global climate change. For instance, as per the study by [3] the carbon sequestered by the shade trees of coffee and cardamom plantation was to the extent of 162 tonnes and 119 tonnes in one hectare area respectively in Kodagu district of Karnataka, India. The farming system that undertakes cultivation of arecanut *(Areca catechu)* is complemented with three unique traditional forms of forestry in the Western Ghats (WG) region of Karnataka.This region is known as the hot spot of biodiversity andthe ever green tropical forestry of WGhosts rich species diversity that further enhances the carbon sequestration capability of the farming system [14]

In this backdrop, it is important to assess the farming system that grows trees as an integral component and thus, acts as terrestrial sinks of carbon beside providing income and livelihood security to the farmers. This may provide an opportunity for a country like India to effectively negotiate in the international forum to envisage proper incentive mechanisms such as Paymentfor Environmental Servers (PES) to the farmers while dealing with emission trading agreements like Kyoto protocol. The study is a modest attempt to assess the carbon sequestration in Areca Based Farming System (ABFS) and its economic implications to the farmers in Western Ghats Regions of Karnataka; India.

Tree Farming in ABFS

Arecanut palm itself is a tree species having high CO_2 sequestering capability. The farming system that is centred aroundarecanut in the Western Ghats region is normally complimented through three traditional forms of forestry. They are (a) *"Soppinabetta"*(also called as *"Kumki" or "Hadya")* in local vernacular - a forestry with local tree species to provide eco-services to areca gardens, (b) Silvi-horti system of agro-forestry of growing tree species along the bunds and inside the plantation, and (c) Homestead forestry that includes multipurpose tree species catering to household food and nutritional security grown in and around the backyard of the dwelling house.

The ***Soppinabetta***(SB) (upland forestry for green manures) is an unique form of agro forestry exists adjacent to areca gardens to extract green leaf manures and for other ecological services to areca based farming system. The 'usufruct' property rights were legally granted to the farmers by the British government during the 18th century at the ratio of 9 acre of *Soppinabetta*land for every acre of arecanut garden. The ecological services including the supply of green leaves from SB are making immense contribution in enhancing the productivity of arecanut. As per a study by [1], the SB with high tree density and natural tree species (to the extent of 82per cent) could provide enormous ecological services that enhanced arecanut yield significantly in the Western Ghats region of Karnataka.

2. DATA AND METHODOLOGY:

Arecanut cultivation in Karnataka is undertaken in two distinct agro-ecological situations; the traditional hilly and coastal areas coming under the purview of Western Ghats (WG) region and the non-traditional *Maidan* (Plain) region. The WG was selected for this study because of the prevalence of more diversified Areca Based Farming Systems (ABFS). For the purpose of analysis the WG region was further classified as Upper Western Ghats (UWG) and Lower Western Ghats (LWG) in order to capture the variation in intra region agro-ecological features. These two regions have the similarities with respect to arecanut cropping system, *Soppinabetta* lands and high rainfall pattern (2,382mm). But UWG region is at higher altitude and is located at higher elevation of the WG, whereas the LWG is in the lower elevation falling in to coastal region. In addition, the population density is relatively higher in LWG compared to UWG. Arecanut is sun dried which is popularly called as White Chali type (WCT) in LWG, whereas it is boiled and coloured to prepare Red Boiled type (RBT) commonly called as *Saraku* in UWG. The Maidan region was taken as control category. The distinguishing feature is that WG region has diverse ABFS with the presence of *Soppinabetta* where as in the Maidan region arecanut is grown as a mono-crop with assured source of irrigation. A random sample of 120 farmers from traditional hilly and coastal region (60 each from LWG and UWG) and 60 farmers from Maidan region (as control) were selected for the study. The data pertain to the crop year 2010-11.

Quantifying the Carbon Stock:

To assess the amount of carbon sequestered or carbon stock in the trees, 'non-destructive method' of biomass estimation was followed.The girth of the tree was measured using the tape at 1.37 m (girth at breast height GBH) and the height is measured using multi-meter. The total biomass (volume x density) was estimated by working out species-wise volume using volume equations of specific species and species-wise specific gravity data. For some species like arecanut, coconut and bamboo biomass was directly calculated using biomass equations given by [2] and [8]. Biomass was converted into quantum of carbon, multiplying it by 0.5 as given by [10].

Carbon stock of arecanut garden, trees in home garden and Silvi-horti system was derived by calculating biomass of the trees with above 30 cm girth at breast height (GBH) present in the ABFS in the study area. The *Soppinabetta* is similar to natural forest and carbon stock is estimated by selecting one representative *SB* forest from each of the village under study by laying out three random plots of size 20m X 30m. Girth at breast height and height of all the trees in the plot was measured. The quantum of carbon obtained for one acre *SB* is used to get total carbon sequestrated by the *SB* land of individual farmer.

Valuation Methods

a) Value of Carbon Sequestrated: The total value of carbon stock was estimated by attaching a price of $20 per tonne of carbon stock. This value is accepted widely in literature [12][4] and [7] as it is the product of a Monte Carlo Simulation [4].

b) Total Use Value: It is the sum of monetary value of arecanut output, taken as direct use value and value of carbon sequestered from ABFS, that is taken as indirect use value.

c) Cost of cultivation of arecanut: As per the methodology adopted in the discipline of agricultural economics, the cost of cultivation of a crop is estimated under two broad categories; namely *variable costs* and *fixed costs.* Within these two cost items, majority are paid out costs and a few are imputed costs for which, the farmers do not make payment directly. The Directorate of Economics and Statistics (DES) under Ministry of Agriculture, Government of India, takes into account all thesecosts while working out the cost of cultivation/ production of principal crops for the purpose of announcing Minimum Support Price (MSP). The arecanut being a perennial crop which takes nearly seven years to get established, the costs during this period is amortized and taken as fixed cost [13].

d) Net Use Value: It is the difference between total use value and total economic costs.

e) Total use value to total cost ratio: It is the ratio of total use value from ABFS to the total cost of cultivation of arecanut.

f) Direct use value to total cost ratio: It is the ratio of direct use value from ABFS to the total cost of cultivation of arecanut.

g)Direct use value to operation cost ratio: It is the ratio of direct use value to the operation costs involved in the cultivation of arecanut

h) Indirect use value to total cost ratio: It is the ratio of indirect use value to the total cost of cultivation of arecanut.

3. RESULTS AND DISCUSSION:

The socio-economic features of the sample farmers in the study region are presented in the table 1. The average age of the respondents was 49 years indicating that the middle age group farmers were engaged in the farming.Though each family consists of five members, hardly two are available for agriculture. The farmers have fairly good literacy rate, schooling up to 13 years i.e. Pre university level, on an average. The study famers have also possessed good number of cattle, up to 6, on an average. This is very crucial as arecanut cultivation is a 'de facto' organic farming for which adequate supply of dung, urine and farm yard manure has to be met from the livestock.

Carbon Stock under ABFS:

Number of trees including areca palms along with the quantity of atmospheric CO_2fixed by the trees under ABFS in the study area is given in Table 2. As mentioned earlier, the ABFS in WG regions is complimented through three types of traditional forestry. The total area under arecanut as well as forestry comes to 15.07 acres in WG which is five times larger than the area under ABFS in Maidan region. The average area under arecanut is 3.45 acres in WG region that also slightly more compared to that of Maidan region (2.73 acres). The average size of Soppinabetta(SB) forestry is 11 acres in WG region, it is higher in UWG region (13.06 acres) compared to LWG (8.93acers). Hence the ratio of arecanut to SB land is 1:2 acres in LWG and 1: 4 acres in UWG. The lesser area under soppinabetta per farm in LWG is attributed to higher population density in LWG compared to UWG [1]. The SB is totally absent in Maidan region. The size of home garden is more in WG (0.62 acres) compared to Maidan region (0.07 acres).

It can be seen from the table that a typical ABFS in the WG region sequestered around 634 tons of carbon in its lifecycle of around 34 years. The highest share of around 451 tons (71 %) comes from SB forestry followed by areca palms (25 %) and remaining share comes from other types of forestry. The CO_2 sequestration capability of ABFS is 30 per cent higher in UWG compared to LWG, due to higher size of SB forestry. The ABFS in the Maidan region, on the other hand, could conserve around 100 tons of carbon that comes mainly from the arecanut garden.

The carbon stock per acre of ABFS i.e. the quantum of carbon sequestered by one acre arecanut garden with the supporting agroforestry systems

Table 1: Socio-economic Profile of Sample Farmers

Sl. No.	Sample farmers	UWG	LWG	WG	Maidan	Overall
1	No.of farmers	60	60	120	60	180
2	Age (Years)	53	46	50	49	49
3	Family Size (No.)	4	6	5	5	5
4	Family members involved in Agriculture (No.)	2	2	2	2	2
5	Education (Years)	13	13	13	12	13
6	Number of Livestock	6	7	6	5	6
7	Social participation (%)	57	60	58	33	50
8	Total Holding Size (acres)	4.49	4.72	4.60	4.21	4.48
9	Area under Arecanut (acres)	3.32 (74)	3.57 (76)	3.44 (75)	2.73 (65)	3.22 (72)
10	Experience of Arecanut Farming (Years)	35	33	34	30	33

Table 2: Carbon Sequestering in ABFS in Karnataka

Sl.No.	Particulars	UWG	LWG	WG	Maidan
1	Area under Arecanut (acre)	3.32	3.57	3.45	2.73
a	No. Of Arecanut trees per acre	557	561	559	517
b	Carbon stock per acre (tones)	42.72	48.00	45.36	34.67
c	Total carbon stock (tones)(1 * 1b)	141.83	171.36	156.49	94.65
2	Area under Home garden	0.57	0.66	0.62	0.07
a	No. of trees per acre	42	53	47	9
b	Carbon stock per acre (tones)	7.49	10.16	8.83	0.67
c	Total carbon stock(tones)(2 * 2b)	4.27	6.71	5.47	0.05
3	Area under Soppinabetta	13.06	8.93	11.00	0.00
a	No. of trees per acre	218	176	197	0
b	Carbon stock per acre (tones)	42.52	39.45	40.99	0.00
c	Total carbon stock(tones)(3 * 3b)	555.31	352.29	450.89	0.00

4	SilviHorti system				
a	No. of SilviHorti trees per acre of arecanut garden	29	24	26	16
b	Carbon stock per acre of Arecanut (tonnes)	5.47	6.97	6.22	1.54
c	Total carbon stock(tonnes)(1*4b)	18.16	24.88	21.46	4.21
5	Total Area under ABFS (acres) (1+2+3)	16.95	13.16	15.07	2.81
6	Total Carbon stock of ABFS (1c+2c+3c+4c)	719.57	555.24	634.31	98.99
7	Carbon stock per acre of arecanut in ABFS (6 / 1)	216.74	155.53	183.86	36.23
8	Age of plantation	35	33	34	30
9	Mean Average Increment of carbon (7/8)	6.19	4.71	5.41	1.20

Table 3: Economics of ABFS in Karnataka

S.N	Particulars	UWG	LWG	WG	Maidan
1	Average Yield (Q/ac)	8.9	9.5	9.2	8.56
2	Average Price (Rs./Q)	14,402	14,025	14,213	14,050
3	Direct Use Value(Rs/acre/year) (returns from Arecanut) (1 x 2)	1,28,177.8	1,33,237.5	1,30,759.6	1,20,268
4	MAI of Carbon (ton/acre /year)	6.19	4.71	5.41	1.20
5	Indirect Use Value(Rs./acre/year)	@ 20$ per tonne one $ = Rs. 60)			
	(value of carbon stock)	7428.00	5655.61	6492.00	1441.78
6	Total Use Value per acre (Rs.) (3+5)	135,605	1,38,893	1,37,251	121,709
7	Total Cost of cultivation of arecanut(Rs/acre/year)	1,27,550	1,09,796	1,18,673	1,20,208
8	Total Operation Costs (Rs/acre/year)	88,105	77,826	82,966	82,378
9	Net Use Value - over Total cost. (Rs/acre/year)	8,055	29,097	18,578	1,501
10	Net Use Value - Operation cost (Rs/acre/year)	47,500	61,067	54,285	39,331
11	Total Use Value to Total Cost Ratio (6/7)	1.06	1.26	1.16	1.01
12	Direct Use Value to Total Cost Ratio (3/7)	1.00	1.21	1.10	1.00
13	Direct use Value to Operation Cost Ratio (3/8)	1.45	1.72	1.58	1.46
14	Indirect Use Value to Total Cost Ratio (5/7)	0.06	0.05	0.05	0.01

comes to around 184 tonnes in WG region and 36 tonnes in Maidan region. The mean annual increment (MAI) of carbon that represents the ratio of carbon sequestered in one acre ABFS to the age of plantation, works out to around 5.41 tons. It can roughly be considered as the annual amount of carbon fixed in one acre of arecanut garden with the associated forestry area.

It is important to note that the carbon stock so estimated pertains only to the biomass of the standing trees. As the trees have continuous growth that takes place in leaves, twigs, branches and other vegetative as well as reproductive parts that are alsoact as carbon sink. These are either harvested or removed regularly and hence not taken in to account here. In the case of areca, not only the nuts (around 9.2 qts. /acre) but also sheath, straw, husk, inflorescence etc. are removed every year. If life cycle assessment of the total biomass of the entire ABFS is made, the volume of carbon sink will be much more than what is assessed above. In addition, the ABFS is unique in terms of green leaf manuring and mulching with in the areca garden that not only sequesters carbon in the soil but also enhances the organic carbon content of the soil. However, some portion of the arecanut by products like sheath, husk and straw are used for fuel and hence burnt. The amount of carbon so released has to be debited while arriving at the net carbon stock of ABFS.Around 0.3 million acres area is under ABFS in WG region of Karnataka, implying the extent of environmental service that the farmers in the region have been rendering silently. The return they could realize for the service may be substantial if a proper pricing of carbon stock and payment mechanism is envisaged. Nonetheless, arecanut being a major commercial crop of the region, its economics has got direct bearing on the sustenance of ABFS as well as carbon sequestration capability of the same.

Economics of ABFS:

Benefits of an agro-ecosystem such as the ABFS can be captured through various values such as ‘use’ and ‘non-use’ values under the larger banner of environmental economics [11]. Return from the arecanut, a direct use value and the ecological services by the ABFS through sequestering the carbon, an indirect use value are the two components of the use value considered for the study. The results pertaining to the costs and returns associated with the use values are presented in table 3.

The yield of arecanut is relatively higher, around 9.20 quintals / acre in WG region compared to the Maidan (8.56qts. / ac). The ecological services from the associated forestry systems especially, from the SBF inter alia supply of green leaf manures, shade, watershed, protection against wind and so on have positive impacts on the yield of arecanut in WG regions.

A cost of around Rs. 1,18,673 ($.1978) / acre is required to cultivate arecanut in WG region. Within which almost 70 per cent is operational costs and remaining 30 per cent is fixed costs. The cost of cultivation in Maidan region is slightly higher. At an average price of around Rs. 14, 213($ 237) / quintal, the farmers producing arecanut could realize a net return of Rs. 18,578($310) and Rs. 1,501($25) per acre in the WG and Maidan regions respectively.

The ratio of direct use value to the total cost of cultivation, that indicates the return from arecanut for every rupee of cost invested comes a paltry 1.10. This implies a return of just 10 per cent over the cost of cultivation of arecanut under ABFS in WG region. The value is just equal to one in UWG and Maidan regions indicating a situation of no-profit and no-loss from arecanut. However, the value of ratio improves substantially, if an operational cost alone is considered. The direct use value to operational cost ratio comes to 1.58 and 1.46 respectively in WG and Maidan regions.

If the value of $ 20 per ton of carbon, as discussed in the beginning is employed, indirect use value of ABFS through carbon sequestration comes to Rs. 6492 ($108) per acre in WG. It is around Rs. 1442 ($.24.) / acre for Maidan region. This meagre payment, if at all materialized, won't make any dent in the overall profitability of the ABFS in the region.

4. CONCLUSIONS AND IMPLICATIONS:

The study has clearly demonstrated the ecological services provided by ABFS in terms of sequestration of substantial carbon (around 634 tonnes per farm). However, as mentioned earlier, financial viability of the ABFS is under stress due to inadequate return for arecanut cultivation. Hence the farmers practicing ABFS in WG region deserve to be compensated adequately for their ecological services to the society. This needs to be addressed at the policy making levels under various agreements and negotiations such as the Green Box provisions of WTO, Payment for Environmental Services (PES) under Kyoto protocol and so on.

However, the slow phase in which the climate change negotiations are moving, it is doubtful even the paltry payment mentioned to be materialized. Surprisingly the Govt. of India is also not considering this issue seriously. The High Level Working Group on Western Ghats constituted by the Ministry Environment and Forestry, Government of India has totally discounted the ecological services of the ABFS while envisaging the incentive system to conserve, protect and rejuvenate the ecology of WG region(Report of HLWG, 2013). The need of the hour is to think seriously towards incentives to the farmers who render such a precious service for the cause of mankind. The Government of India should evolve an unique incentive system so that other countries having similar ago-eco system undertropical forestry could emulate and join hands with India while negotiating in the international forum.

An ideal incentive system under this circumstance should consider the 'opportunity cost' of the land that is devoted for ABFS as the carbon sink. The 'resource rent' is normally considered as the opportunity cost of the land, which works out to Rs. 4451 ($.74) per acre in the study area. An incentive equivalent to the rental value of the land devoted for ABFS will give not only financial stability but also much needed moral strength to arecanut farmers who are caught up with severe crisis and several problems such as lethal pests and disease attack, price volatility, import surge and recurrent legal interventions like banning the consumption of some of the value added products like Gutka.devoted for ABFS will give not only financial stability but also much needed moral strength to arecanut farmers who are caught up with severe crisis and several problems such as lethal pests and disease attack, price volatility, import surge and recurrent legal interventions like banning the consumption of some of the value added products like Gutka.

REFERENCES

[1] Arun Kumar, S., 1996, Agroforestry in Arecanut Farming system of Western Ghats-An Economic Analysis. *M.Sc.(Agri.) thesis (Unpublished)*, Department of Agricultural Economics, UAS, Bangalore.

[2] Brown, S., 1997, Estimating Biomass and Biomass change of Tropical Forests: A Primer. A Forest Resources Assessment Publication, FAO Forestry Paper 134, Food and Agricultural Organization of the United Nations, Rome.

[3] Devakumar, A.S., Babu, K., Eashwar Reddy, N.V. and Anand, B., 2012, Carbon stock assessment in Arecanut and shade trees of Coffee and Cardamom plantations. Indian Journal of Agroforestry, 14(1):80-83.properties", *J. Indian Soc. Soil. Sci*., 29: 1981, pp.81-85.

[4] Fankhauser, S., 1995, Evaluating the social costs of Greenhouse gas emissions. CSERGE working paper GEC 94-1, CSERGE, University College, London.

[5] HLWH , 2013, Report of the High Level Working Group on Western Ghats, Vol 1, Ministry of Environment and Forests, Government of India, New Delhi

[6] IPCC (Intergovernmental Panel on Climate Change), 2000, Land use, Land use change and Forestry.Cambridge University Press, Cambridge, UK.

[7] Kremen, C. Niles, J.O., Dalton, M.G., Daily, G.C., Ehrlich, P.R., Fay, J.P., Grewal And Guillery, R.P., 2000, Economic Incentives for Rain Forest Conservation across scales. Science, 288: 1828 - 1832.

[8] Kumar, B.M., Sudheesh, K.G. and Rajesh, G., 2005, Standing stock of thorny bamboo (Bambusabambos (L.) voss) in the Home gardens of Thrissur, Kerala) Trop. Agric,43(61-68)

[9] Macdickens, K.G., 1997,A guide to Monitoring Carbon Storage in Forestry and Agroforestry, Forest carbon monitoring program, Winrock International Institute Publication,pp,1-87.

[10] Pearce, D., 2002, Economic Valuation with Stated Preference Techniques-Summary Guide. Department for Transport, Local Government and the Regions: London, UK.

[11] Pearce, D., Whittington, T., Georgiou, S. and Moran, D., 1994, Economic values and the environment in the developing world: A report to the United Nations Environment Programme-Nairobi. The Centre for Social and Economic Research on the Global Environment, London, UK.

[12] Prakash Kammardi, T.N., 2012, Arecanut Economy at the Cross Roads, Report of the Special Scheme of Cost of Cultivation of Arecanut in Karnataka, Dept. of Agricultural Economics, UAS, Bangalore.

[13] Tejaswini,A.B.,2013, Areca Based Cropping system (ABCS) and Climate Change-An Environmental Economics study in Western Ghats region of Karnataka. *Ph.D. thesis (Unpublished)*, Department of Agricultural Economics, UAS, Bangalore.