SUSTAINING PRODUCTIVITY OF COASTAL WETLAND AGRICULTURE: A STUDY OF THE KOLE WETLAND IN INDIA

MAINTENIR LA PRODUCTIVITE AGRICOLE DES REGIONS HUMIDES COTIERES : ETUDE DE LA REGION HUMIDE DE KOLE EN INDE

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ABSTRACT

The Kole land, is an important Ramsar wetland in South of India. This wetland ecosystem lies submerged under water for almost six months in a year. Rice is a major crop cultivated in this region after dewatering of fields, which lie 0.5 to 1.5 meters below the mean sea level. Dewatering of fields is carried out with the withdrawal of monsoon season and the water is collected in canals for irrigation during summer. This challenging water management is labour and energy intensive and is carried out in a collective manner by the farmers. For almost last twenty years high yielding varieties of rice are cultivated here. The Kole lands have a net work of canals and zonal system of cultivation in which flood water is managed in an interesting way in this region. Zonal cultivation is one in which cultivation starts from zone 1 which is at a higher elevation. Flood water from that zone is collected in zone 2, a lower elevation area. Water collected in zone 2 is used as irrigation water in zone 1. Then cultivation in zone 2 is taken up and water is collected in zone 3, etc. This paper examines the productivity of rice and its economic and ecological sustainability. It is found that high productivity of rice is maintained with higher input use and at a higher cost of production as a result of which it is not economically sustainable in the long term. There is a need to explore alternative ways of rice cultivation in which the land and water productivity is optimised.

Key words: *Kole lands, Rice cultivation, Wetland ecosystem, Kerala, India.*

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RESUME

La Région Kole est une importante zone humide de Ramsar au sud de l'Inde. Cet écosystème des zones humides reste submergé sous l'eau pendant six mois d'un an. Le riz est une culture importante de cette région. L'assèchement des champs est réalisé avec le retrait de la mousson et l'eau est recueillie dans les canaux d'irrigation en été. La gestion d'eau qui exige beaucoup de main d'oeuvre et d'énergie pose un grand défi et est réalisée de manière collective par les fermiers. Depuis vingt dernières années, les variétés de haut rendement du riz sont cultivées dans cette région. La région Kole possède un réseau des canaux et du système de culture par lequel l'eau est gérée de manière intéressante. La culture commence à partir de la zone 1 qui se trouve à une altitude plus élevée. Les eaux de crue provenant de cette zone sont recueillis dans la zone 2, une zone de basse altitude. L'eau recueillie dans la zone 2 est utilisée comme l'eau d'irrigation dans la zone 1. Ensuite, la culture dans la zone 2 est pris en charge et l'eau est recueillie dans la zone 3, etc. Cet article examine la productivité du riz et sa viabilité économique et écologique. Il est constaté que la haute productivité du riz est maintenue avec l'utilisation efficiente d'intrants à un coût plus élevé de la production. Par la suite, il n'est pas viable de point de vue économique à long terme. Il est nécessaire d'explorer d'autres moyens de cultiver le riz dans lequel la productivité des terres et de l'eau est optimisée.

Mots clés : *Région Kole, culture du riz, écosystèmes des zones humides, Kerala, Inde.*

1. INTRODUCTION

Wetlands, facing several threats are highly fragile complex ecosystems that provide variety of services to the society. However, the global area of wetlands has decreased at an ever-increasing rate during the course of the century (Matthews and Fung, 1987, cited in Adger and Luttrell, 2000). Of the total wetland area lost, 87% accounts for the diversion to agricultural development, 8% to urban development, and 5% to other conversions (Barbier 1997). The loss of wetlands tends to have profound ecological impacts. Moreover, as growing demand for food production accentuates pressures on wetlands the interactions between agriculture practices and wetlands assume greater importance. Although the Millennium Ecosystem Assessment identifies agriculture as a major driver of wetland degradation and loss, agricultural development considerably increases some of the provisioning services of wetlands, though some other regulating and supporting services may get reduced in the process. In a recent Comprehensive Assessment (CA) of Water Management in Agriculture, it has been concluded that the pressures on wetlands will probably increase, with the prospect of a serious loss of wetlands and their ecosystem services. This is pointed out as a major challenge as the regulating and supporting ecosystem services that wetlands provide are essential for the functioning of river basins, the maintenance of ecological flows, and the sustainability of agricultural production (FAO, 2008). In this paper, we present a case study of the Kole land, a Ramsar wetland in Thrissur, Kerala, India.

2. THE KOLE WETLAND

The Kole land, one of the rice granaries of Kerala is a unique wetland ecosystem down South of India. It is part of Vembanad-Kole wetland system spread across about 1513 km^2 and is the largest wetland system in India, included as a Ramsar site in 2002. Geologically, Kole is a low lying area with rich alluvium deposits brought along by Kechery and Karuvannur rivers. According to the earlier official estimates, the Kole rice fields are low lying tracts located at 0.5 to 1 m below mean sea level extending to an area of 136.32 km^2, spread over Thrissur and Malappuram districts of Kerala. The southern boundary is marked by Chalakudy river while northern boundary by Bharathapuzha river. The area is located between 10°20' and 10°40'N latitude and 75°58' to 76°11'E longitude. The Kole land in Thrissur district is located in Mukundapuram, Thrissur and Chavakkad *thaluks*, where as Ponnani Kole is located in Chavakkad and Thalapilly *thaluks* of Thrissur district and Ponnani *taluk* of Malappuram district.

A major portion of the Kole land remains submerged under water for about six months in a year lending it both terrestrial and water related properties. A network of canal connects different regions of the Kole to the rivers besides acting as good drainage systems. Rice cultivation is carried out in the Kole land after dewatering the fields when the monsoon withdraws.

Rice is the most important crop cultivated in the Kole land. The crop seasons are as follows: *Virippu* is usually cultivated in higher rice fields around the Kole land where the duration of floods lasts only for a few days. Here sowing is carried out with the onset of monsoon and by the time flood water reaches the field, the crop will be been 30-40 days old. Varieties which can withstand floodwater for a few days are usually cultivated in *Virippu*. Mundakan is cultivated on medium elevation fields around the Kole land where flood water recedes by August. *Kadumkrishi* in Kole land coincides with *Mundakan* across normal lands, but usually it starts by September. However, in order to undertake *Kadumkrishi*, the Kole land is protected by bunds. When flood waters in the Kole field start subsiding by the end of South west monsoon season, pumping out of water is carried out in 10 to 15 days. Dewatering is carried out using *petti* and *para* which is an indigenous axial flow pumping device developed for dewatering the Kole field. After this, bunds around the fields or *padavu's* are raised and strengthened by means of locally available materials and laterite soils to a height of 1 to 1.5 m above the field level. Crop is directly sown or transplanted when water is around 10 to 15 cm deep. In *Kadumkrishi* water management is very important as it requires continuous pumping out of water and towards the end of the crop season and there is a need for supplying irrigation water as well.

Punja is a crop raised across the entire Kole area. Water requirements for *punja* in the early stages of crop are met with summer flow in the rivers and storage canals and in later stages, water from dams is used for irrigation. Since late 1980s, the North Kole is divided into three zones for *Punja* cultivation. Usually in the first and second zones, only *punja* is taken and in the third zone an additional crop or *kadumkrishi* is also raised. Under the zonal system, dewatering is carried out zone wise. Water pumped out from one zone is collected in other zones and used as irrigation water as and when required. Dates are specified in advance for starting and ending dewatering in each zone by the District Administration in consultation with *Padasekhara Committees* (Farmers' cooperatives) who carry out pumping operations. The normal practice is to start dewatering by second week of November and complete sowing by first week of December in zone 1. Water pumped out of zone 1 will be collected in zone 2 which in turn is used as irrigation water for zone 1 and zone 3. Zone 3 would be under *mundakan* crop by then. The *mundakan* crop would have started by third week of September and lasts until end of December. Once the harvest is completed, by December end, water from Zone 2 is pumped out and stored in zone 3. Zone 3 would be under water for almost one month after which the fields will be prepared for *punja* crop. The water which is now pumped out of zone 3 would be stored in the Kole canals for summer irrigation. Cooperation and collective action by farmers are very important in this zonal system. In order to maintain water levels, the Enamakkal regulators, Munayam bund, Chirakkal *thodu* (flowing water body) and Herbert canals are all closed on specified dates. Additional irrigation water requirements are met with Peechi and Chimony dams. The farmers consider the zonal system of cultivation as, the most practical and convenient way for undertaking cultivation in the Kole fields by managing flood water in an efficient manner.

A few decades back, a number of local varieties of rice used to be cultivated on the Kole fields. Over the last few decades, *Jyothi*, Uma and Jaya varieties of rice have come to be cultivated. Earlier seeds used to be prepared by farmers themselves, however, now they are supplied by the National Seeds and Karnataka Seeds Corporation (mainly Uma). Farmers are given various types of subsidies for carrying on rice cultivation on the Kole fields. This includes subsidies for dewatering, purchase of seeds, fertilisers, and pesticides. Harvested rice is procured through Civil Supplies Corporation. The Kole rice farms are either marginal or small in nature and pose several challenges in cultivation. But for the cooperative approach, the otherwise hostile region is beyond the means of cultivation by individual operators. Against this background, we analyse the productivity as well as the economics of rice cultivation and identify major opportunities as well as constraints in sustaining rice production in the Kole rice farms.

3. OBJECTIVES, DATA AND METHODOLOGY

The prime objective of this study is to examine the productivity of rice in the Kole wetland and its economic and ecological sustainability. A detailed survey of Kole rice farming households over the period December 2009 to April 2010 using a structured questionnaire on various aspects of paddy cultivation. the most important direct agricultural use of Kole wetlands, have been carried out. As nearly ninety five per cent of the farmers surveyed were found cultivating rice in a single crop season, the analysis presented in this report pertains to a single crop season only. Besides, details of various inputs including material inputs, their quantities and prices, and managerial inputs apart from rice output collected and valued in monetary terms for examining the net returns and profitability aspects. Information collected on hired and family labour, both males and females separately is used to identify the most labour intensive activities. The value of family labour has been imputed at the existing average wage rates for males and females, respectively. A Cobb-Douglas production function (log linear) has been fitted for examining the input-output relationship and for estimating returns to scale. In order to examine the economic viability of Kole farming, net returns have been estimated by taking the difference between gross value of output and the total variable cost of cultivation including the input cost of family labour. We have also calculated the ratio of gross value of output to total costs to see the extent of profit margin and also to identify farmers who find rice cultivation viable and not viable.

Sample selection

It may be mentioned that Kole rice farms are organised under an institutional arrangement called *Padasekharams* which is a cluster of farms. Therefore, in the first stage of sample selection, based on the availability and access to baseline information particularly on the number of farmers and their farm size, we purposively selected *padasekharams*, arbitrarily classifying them into small, medium and large. Further, farmers in the selected *padasekharams* were stratified based on their size of landholding. Approximately 10% of the farmers from each stratum were selected for an in-depth study adopting probability based proportionate sampling method (Table 1). Of a total of 231 farmers surveyed 49 farmers (21%) reported non-cultivation of rice for the reference period[2], (2008-09 crop season) and as such were excluded from a detailed analysis. Out of the 182 farmers who reported cultivation, nine were small farmers having one to two hectares of land while the rest (95%) of the marginal farmers were found with less than one ha of land. This is in line with the trends observed in Kerala overtime.

Table 1. Details of the sample *padasekharams* selected for the study

Size of padasekharam	Name of the Padasekharam	Total No. of farmers	No. of Sample farmers
Small	Anayuruli Harijan Kole	47	7
	Nelkathir Kole Karshaka Samithi Kizhakku Mathamathoppu	43	7
	Muriyadu Kayal Maadayikkonam Thekkeppadam Kole Karshaka Samithi	197	23
Medium	Jubilee Thevar Padavu Kole Karshaka Samithi	697	63
Large	Chemmanda Kayal Periyapadam Kadumkrishi Karshaka Sahakarana Sangham	1016	131
All		2000	231

4. RESULTS AND DISCUSSIONS

4.1. Rice Cultivation in the Kole Land

a. Average size of landholdings and yield of rice per hectare

The average size of individual land holdings across all *padasekharams* in the Kole land works out to 0.36 ha (Table 2). Marginal farmers hold an average area of 0.31 ha while small farmers 1.25 ha. The average the size of individual holdings is lowest at 0.33 ha in the large *padasekharam* followed by small *padasekharam* with 0.35 ha.

2 The important reasons reported for not cultivating paddy include labour problems and lack of profitability.

Table 2. Average size of landholding and yield of rice per hectare in the Kole land by size class of *padasekharam* and landholding

Size class	Average area (ha)	Average yield (kg/ha)
Padasekharam		
Small	0.35	4793.45
Medium	0.40	5287.99
Large	0.33	5221.80
Landholding		
Marginal	0.31	5162.05
Small	1.25	5065.36
Total	0.36	5157.27

Source: Primary survey

A comparison of per hectare yield of rice from Kole land farms with that of Kerala and India as a whole confirms the widely held view that yield levels of rice from Kole land farms are very high. The average yield of rice per hectare from Kole farms is found to be 5162 kgs as against 3705 kg/ha for Kerala during 2006-07. The corresponding all India figures work out to 2145 kg/ha for 2007-08 which in fact had registered an increase from 2074 kg/ha for 2006-07 (CACP, 2010). The high levels of yield found in Kole land farms are generally not observed in several places in India. For instance, within India, Punjab leads with a yield level of 4019 kg/ha, followed by Haryana (3361kg/ha), Andhra Pradesh (3344kg/ha) and Tamil Nadu (2817 kg/ha) (CACP, 2010). Also, there is no statistically significant difference between the yield levels of marginal and small holdings and also between medium and large *padasekharams*. However, it is also a widely held view that high levels of yields are maintained with a higher input mix and, therefore, at a higher cost of production.

b. Input use in the Kole rice cultivation

The first step in undertaking rice cultivation is dewatering of fields. The whole process of dewatering using *petti* and *para* is energy intensive but is provided free of charges to *padasekharams* by the government. Labour and other costs incurred for dewatering are shared by the individual farmers according to the size of their land holdings. After dewatering, land tilling, mostly using power tillers, and construction of bunds is carried out by farmers independently. Power tillers for tilling are used for nearly 15 h/ha. At this stage, lime is applied to the soil. As soil in the Kole land is acidic in nature, application of lime based on requirement and letting in water and subsequent drainage are absolutely necessary for correcting acidity content and associated toxicants. Almost 90% of the farmers have reported lime application on their fields. The average quantity of lime applied is 267 kg/ha (Table 3). Besides lime, roughly 44% of the farmers have reported application of organic manure at the time of land preparation. When compared to 192 kg/ha of organic manure applied in Kerala, for Kole rice lands it is 160 kg while the medium *padasekharams* have reported the lowest average of 70 kg/ha. Across both size classes of farmers, although marginal farmers applied slightly higher quantity of organic manure, the mean difference is not statistically significant. It is estimated that about 150 kg/ha of seeds are used for cultivating rice in the Kole land farms. A high seed rate in the study area has been observed in some of the earlier studies as well (Johnkutty and Venugopal, 1993). Farmers are tempted to use more seeds because of the fear of seed germination problems and survival of plants and also due to the presence of acidic and other toxic elements in the soil systems. Both broadcasting of seeds and transplanting of saplings after raising them in seed beds are in practice. However, only 10 farmers of those surveyed have reported the use of any transplanting machine.

Table 3. Use of input mix per hectare in the Kole land rice cultivation

Size class	Tiller (hrs)	Lime (kgs)	Organic manures (kgs)	Seeds (kgs)	Chemical fertilisers (kgs)	Insecticide (Rs)	Labour (days)
Padasekharam							
Small	13.38	258.58	208.85	154.25	250.78	1727	204.24
Medium	14.25	243.45	69.8	155.76	315.27	2084.12	159.53
Large	15.57	287.72	206.63	141.74	270.86	1665.64	176.54
Landholding							
Marginal	14.91	269.87	163.47	149.77	275.05	1844.62	178.48
Small	10.21	206.2	102.72	135.34	413.78	1360.53	135.88
Total	14.67	266.72	160.47	149.06	281.91	1820.68	176.37

Source: Primary survey

Use of chemical fertilisers per hectare of rice is found two times more than that of all Kerala average. While the quantity of chemical fertilisers used comes 123 kg/ha for Kerala (CACP, 2010), it is as high as 282 kg/ha for the Kole fields. Across different size classes of *padasekharams*, relatively higher amounts of fertiliser use have been observed in the case of medium size *padasekharams* which incidentally have reported smaller amounts of organic manure application. When compared to marginal cultivators, small cultivators use almost one and half times the quantity of chemical fertilisers. A mean difference of 139 kg/ha of fertiliser use in rice land with respect to small and marginal farmers is found statistically significant at 1% level.

The use of pesticides and weedicides is also high in Kole land farms. Various types of weeds such as *Cyperus Rotundus, Cyperus Difformis, Fimbristylis Miliacea, Marsilea Quadrifolia, Oryza Rufipogon, Ischaemum Rugosum, Echinochloa Crusgalli, Monochoria Vaginalis, Cynodon Dactylon, Sacciolepis Interrupta, Marsilea Spp* are found here. Both manual weed removal and use of weedicides are practised in the Kole land farms. Similarly, various types of plant diseases at various stages of plant growth are also reported. On an average, insecticides worth Rs 1820[3] are applied per hectare of land. Here again medium size *padasekharam* have reported higher use.

3 Rs is Indian rupees (INR). 1 INR = 0.0224 US dollars approximately.

A look into the labour input shows that it is almost twice the average labour use reported for all Kerala. Almost 176 human days are employed per hectare of Kole land rice cultivation whereas it was 98 man days during 2006-07 for all Kerala as per the reports of the CACP (2010). Highest amount of labour use has been reported from small *padasekharams*. Activity wise, labour use shows that almost 32 per cent of the total labour force is used for land preparation and construction of bunds followed by 21 per cent for weed control including manual removal and application of weedicides etc. In the focus group discussions also, farmers have pointed out that weed control and management has become a serious problem in the recent years. The next major share of labour is used for transplanting of rice plants (17 per cent) and 15 percent for harvesting and threshing operations. Here it is to be noted that the use of machines especially for transplanting and harvesting is dismal due to various reasons such as the non availability of adequate number of machines whenever needed, and the small size of holdings etc, while labour used for disease control accounts for about 6.50 per cent. On the whole, it is seen that a higher yield of rice per hectare in the Kole land is attained with a higher per hectare input mix.

c. Estimation of Cobb-Douglas production function

The following Cobb-Douglas production function (log linear) has been fitted to examine the input-output relationship and also to estimate returns to scale.

$$LnY_i = \beta_0 + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \beta_4 LnX_{4i} + \beta_5 LnX_{5i} + \beta_6 LnX_{6i} + \mu_i$$

Where LnY = log of rice yield in kilograms per hectare; LnX_{1i} = log of labour used per hectare in labour days; LnX_{2i} = log of quantity of chemical fertilisers used per hectare in kilograms; LnX_{3i} = log of value of pesticides and weedicides applied per hectare in Rupees; LnX_{4i} = log of use of power tillers for land preparation in hours per hectare; LnX_{5i} = log of quantity of seeds used per hectare in kilograms; LnX_{6i} = log of other costs incurred per hectare in Rupees; μ_i = random error term.

Water is assumed to be a non-binding factor because of favourable irrigation conditions as reported by the farmers and not explicitly included as an input variable in the regression. However, the cost incurred, if any, on irrigation is included in X_6 (other costs).

The sign and significance of the estimated coefficients of the Cobb-Douglas production function indicate that seed, application of chemical fertilisers and insecticides, human labour, and tilling hours influence yield levels to a great extent. The coefficients for seed and chemical fertilisers are found of higher magnitude indicating a higher marginal efficiency with respect to these two inputs (Table 4).

Table 4. Estimated Production function of rice

Variables (in Logs)	Coefficient	Std. Error	t value
Labour used per ha in labour days (X_1)	0.108542**	0.052438	2.07
Qty of chemical fertilisers used per ha in kgs (X_2)	0.143275*	0.040992	3.5
Value of pesticides and weedicides applied in Rs per ha (X_3)	0.134541*	0.032686	4.12
Use of power tillers in hrs per ha (X_4)	0.105578**	0.049064	2.15
Qty of seeds per ha in kgs (X_5)	0.22611**	0.097226	2.33
Other costs in Rs per ha (X_6)	-0.02817	0.038963	-0.72
Constant	5.005403*	0.637123	7.86
Number of obs = 182 F(6, 175) = 11.04; Prob > F = 0.0000 R-squared = 0.2745; Adj R-squared = 0.2497			

*, ** are respectively 1 and 5 per cent level of significance
Source: Primary survey

The coefficient of the variable X_6 (other costs) although had an unexpected negative sign was however not significant. While a study conducted by Muraleedharan (1987) had reported constant returns to scale (1.10), in the present study returns to scale is found to be only 0.69 indicating that cultivation of rice in the study area is at a diminishing returns to scale.

d. Economic viability of rice cultivation in the Kole lands

In order to see the economic viability and sustainability of rice cultivation in the Kole farms, it is important to look into the costs and returns for farmers. Details of various inputs used including material inputs, their quantities and prices, and managerial inputs apart from rice output have been collected and valued in monetary terms for examining the net returns and profitability aspects. Information on hired labour and family labour, both male and female, was collected separately with value of family labour imputed at the existing average wage rates for males and females respectively. It is seen that irrespective of the size of the landholding or *padasekharam*, the cost of cultivation of rice per hectare amounts to about Rs 45588 (Table 5). Based on landholding size, the cost of cultivation shows that small cultivators incur a significantly lesser cost. While the cost incurred by marginal farmers works out to Rs 46503 per hectare, it is only Rs 27983 for small cultivators. The mean difference of Rs 18520 across small and marginal farmers is found statistically significant at 5 per cent level of significance. On the other hand, small *padasekharams* are found to have incurred higher cost of cultivation which is also statistically significant. This could be because small *padasekharams* and marginal holder cultivators are not in a position to take advantage of economies of scale. Among the components of costs considered here, labour cost forms the single largest variable accounting for 65 per cent, while the costs incurred on other inputs vary between 3 to 8 per cent of the total cost. It is seen that small farmers incur approximately 10 per cent less cost on labour and relatively higher cost on fertilisers as compared to marginal farmers.

Table 5. Cost of rice cultivation (Rs/ha) in the Kole land

Size class	Labour	Tilling	Seed	Organic manure	Lime	Fer-tiliser	Insecti-cides	Other costs	Total input cost
Padasekharam									
Small	34253	2717	2048	2275	1422	1630	1727	4321	50393
Medium	26709	3128	2315	671	1339	2049	2084	3590	41885
Large	29594	3578	2108	2652	1582	1760	1665	3271	46211
Landholding									
Marginal	30285	3297	2188	1972	1484	1788	1844	3644	46503
Small	15579	2335	1746	530	1134	2690	1360	2608	27983
Total	29558	3250	2166	1900	1467	1832	1821	3593	45588

Source: Primary survey

In order to see the economic viability of Kole rice cultivation, one has to look into the profitability aspects. The farmers growing rice in the Kole farms are found to have realised a gross return of Rs 56730/ha (Table 6).

Table 6. Comparison of costs and returns (Rs/ha) on rice cultivation in the Kole farms

Size class	Gross value of output	Cost of production	Net returns	Ratio of gross value of output to cost
Padasekharam				
Small	52728.00	50392.97	2335.02	1.30
Medium	58167.94	41885.35	16282.60	1.70
Large	57439.78	46210.92	11228.86	1.53
Landholding				
Marginal	56782.54	46503.42	10279.12	1.49
Small	55718.95	27982.89	27736.06	2.58
Total	56729.95	45587.57	11142.38	1.54

Source: Primary survey

Output has been valued at the price received by the farmers. The average net return from rice cultivation is found to be Rs 11142 per hectare. This is as low as Rs 2335 for small *padasekharams*. While small cultivators are found to have obtained a net return of Rs 27736 per hectare, it is as low as Rs 10279 for marginal holders. In order to see the level of margins, we also have worked out the ratio of gross value of output to total costs. The ratio shows that the gross value of output exceeds the costs across different size classes of *padasekharams*, as well as landholding classes. While the ratio is found to be 1.54 for all categories of farmers, it ranges from 1.30 for small *padasekharams* to 2.58 for small cultivators (Table 6). It is, however, significant to point out that for almost 32% of the sample farmers, the ratio of gross value of output to total cost per hectare works out to less than one, indicating that cultivation of rice is not economically viable for them- the average ratio is found to be 0.74 for them. For another 43% of the farmers, the ratio of gross value of output to total cost has been found between one and two with an average of 1.42. For these farmers, even a marginal increase in the cost of production or a decrease in the gross value of output or both would make rice cultivation economically non-viable, possibly forcing them to give up rice cultivation. These two categories together comprise almost 75 per cent of the total number of farmers in the Kole land. It is seen that the degree of margin or profitability improves with the size of holding. The correlation coefficient between the size of land holding and the degree level of margin has been found to be 0.34 and is statistically significant.

5. SUSTAINING RICE CULTIVATION IN THE KOLE LAND: CHALLENGES AND OPPORTUNITIES

What are the opportunities and constraints that farmers face due to ecosystem related characteristics, input-output and institutional and other services related factors? What roles can farmers and the state play in sustaining rice production in the Kole land?

The biggest opportunity for undertaking rice cultivation in the Kole land is the fact that it is a flood plain area and therefore, a highly fertile area. In spite of decades of investment in basic infrastructure for broad based agricultural growth, inadequate and in some places incomplete construction of bunds and canals and their inadequate maintenance are posing major problems resulting in poor drainage and waterlogging of Kole land leading to faster weed growth and euotrophication of wetlands. Therefore, proper maintenance of canal networks needs to be ensured by the state with cooperation of farmers. Any infrastructural development project should consider the ecosystem characteristics so as to prevent further subdivision and fragmentation of the farms as marginal farms and small *padasekharams* are found to be economically unviable. The zonal system of cultivation has to be continued with greater participation of farmers.

While activities which tend to alter ecosystem and its services and those that are conflicting in nature like mining need to be banned or controlled by the state, the farmers themselves have to refrain from introducing such uses in the future. The *padasekharams* can play an important role in preventing introduction of unsustainable use of the Kole land by such farmers. Better coordination between rice cultivation and fish farming activities which are carried out in alternate seasons needs to be ensured.

As far as rice cultivation is concerned, labour is a major input contributing about 65% of the total cost of production. However, substituting labour with machinery in activities like land preparation, transplanting, weeding, harvesting etc leads to high transaction costs because of small farm size and lack of timely availability of machines that are suitable to Kole farms. In order to overcome some of the constraints imposed by the small size farms one must emphasise the fact that substantial benefits can be realised through collective effort particularly through *padasekharams*. This may necessitate an expansion in the sphere of activities of *padasekhara samithis* and possibly encourage collective action right from the first to last stage which would allow farmers to reap some economies of scale that are generally associated with large farms. A better coordinated and planned farming activity by individual farmers within a *padasekharam* might help them to minimise labour cost by some extent. Also there is a need to develop machines that are suitable for Kole farms which are small in size and ensure their timely availability by the state.

Use of chemical fertilisers and pesticides is very high in Kole land. There is a need to have a relook into the subsidies given by the state for these inputs as well as to promote environment friendly farming practices taking into account both health and food safety aspects. Towards this end, there is a need to encourage farmers to go in for more organic way of farming and replenish the soils. This is important as rice cultivation is already witnessing diminishing returns to scale. Shortage of organic inputs and their higher prices in comparison to chemical inputs was reported by many farmers as a major reason for higher use of chemical inputs. Measures may be taken by the state to improve supply of organic inputs at reasonable prices to encourage its use as it might improve soil quality and resilience of the ecosystem.

The small scale nature of the Kole farms leads to high unit transaction costs in almost all input transactions. In the current situation, there is lack of proper information for the farmers on the services provided by various government departments and agencies to the farmers. Therefore, removal of information asymmetries as well as ensuring quality and efficiency of service delivery by various institutions involved in Kole land management and development in a coordinated manner is of considerable importance for sustaining rice cultivation.

As a long term objective, there is a need to look for alternative farming practices considering the seasonally inundated nature of the ecosystem in which input costs including labour and energy are minimised. Review of different farming practices in similar seasonally inundated wetlands within the state and elsewhere and their suitability in the present study context needs to be explored and researched.

6. SUMMARY AND CONCLUSIONS

The Kole land, which is a flood plain of Karuvanoor and Kechery rivers in Kerala, India is an important Ramsar wetland. It is a complex ecological system which lies submerged under water for about six months in a year giving it both terrestrial and land related properties and generates substantial benefits to the society. Rice is a major crop cultivated in this region after dewatering of fields, which lies 0.5 to 1.5 meters below the mean sea level. For almost last twenty years high yielding varieties of rice are cultivated here. The Kole lands have a net work of canals and zonal system of cultivation in which flood water is managed in an interesting way is practiced in this region. Zonal cultivation is one in which cultivation starts from zone 1 which is in a higher elevation area and flood water from that zone is collected in zone 2, a lower elevation area. Water collected in zone 2 is used as irrigation water in zone 1. Then cultivation in zone 2 is taken up and water is collected in zone 3, etc. Kole in the regional language means bumper harvest in favourable conditions and refers to the high productivity of the system.

In this study, we examine the productivity of rice and its economic and ecological sustainability. A detailed survey of rice farmers have been carried out to examine the economics of rice cultivation and to identify the major opportunities and challenges in sustaining productivity of the Kole rice fields. It should be noted that Kole rice farms are organised under an institutional arrangement called *padasekharams*. In the first stage of sample selection, we purposively selected *padasekaharams* after classifying them into small, medium and large. Farmers in the selected *padasekharams* were stratified based on their size of landholding and approximately 10 per cent of the farmers from each statum have been selected for detailed survey. A Cobb-Douglas production function has been estimated to examine the input-output relationship and returns to scale. In order to identify economic viability of rice cultivation we estimated net returns from rice cultivation and also calculated the ratio of gross value of output to costs.

It is seen that the average yield per hectare of land is comparatively high. However, this high yield is maintained with higher input use. Use of seeds, chemical fertilisers, pesticides and labour are much higher than the average figures for all India and for the state of Kerala. The Cobb Douglas production function shows that the above variables are significantly influencing output. However, the returns to scale shows that Kole rice cultivation is taking place under diminishing returns to scale. It is also seen that small *padseskharams* as well as marginal farmers are incurring higher cost of production and therefore lower net returns. The ratio of gross value of output and total variable cost is also lower for them. Almost 65 per cent of the cost is incurred for labour, of which a major portion is for dewatering and preparation of land. The cost estimates does not include the cost of energy which is supplied free of cost by the state government. The analysis raises questions on the sustainability of the system. On the one hand, it seems to be not economically viable to marginal farmers who form the majority. On the other hand, indiscriminate use of chemicals and lack of proper maintenance of irrigation systems poses threats to ecological sustainability. In a place where there is high labour shortage, there is a need to evolve innovative measures to maximise land and water productivity while ensuring its economic and ecological sustainability. One such measure is to go back to the traditional system of rice cultivation which avoids dewatering of fields and where rice is grown in water. This would optimise both land and water productivity. There is a need for further research to see the viability of reintroducing the traditional system of cultivation in the changed socio economic environment and from the point of view of enhancing food production, land and water productivity on a sustainable basis.

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