Theme- Balancing Nature: People, Biodiversity and Resilience

Agrarian Distress and Sustainable Livelihood Opportunities in Kuttanad in Kerala (India)

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Introduction

The paper discusses the agricultural situation in Kuttanad, the "Rice Bowl" of Kerala in India, which is renowned for not only its rice fields but also is a favorite tourist destination. This region has evinced keen interest in environmentalists, scientists and policy makers for its unique rice cultivation system, which was developed over 52,000 acres by reclaiming the lake area by a novel method, which dates back to 1833.The entire area is 2 meters below the sea level. Transformation from the lake to paddy fields has enabled paddy cultivation. This region, before the enactment of the Land Reform Legislation was a huge agricultural tract owned by a few landlords, who were responsible for reclaiming and making the land fit for cultivation. In the 70s with the passing of the Land Reform Bill there was a redistribution of land to the landless farmers and tenants. Historically, Kuttanad region was found highly suitable for rice cultivation. The land in this region is made fertile by the silt brought in by the river systems. The unique feature of this land is that it is reclaimed. Recent trends show a perceptible decline in the area under rice cultivation. The farmers are de motivated to cultivate due to various reasons like rising costs of inputs, shortages of labor, uncertainties of weather and unviable price of paddy. In fact the farmers are ready to sell their land for commercial purposes, though the Land Use Act forbids the use of land for purposes other than that of farming. In the wake of the Green Revolution Programme initiated in India in the 60s, Kuttanad also adopted the package of measures intended to increase agricultural production to meet the growing demand for food grains. Rice production increased substantially with the use of chemical based farming. However, this step and other development strategies culminated in a situation of ecological disaster and environmental pollution. The use of chemical inputs led to increased pollution and has jeopardized the living conditions of the people. The ecological uniqueness of the area itself became a contributory factor to the ecological decay and livelihood loss. Kuttanad , which was once considered as the ‘Rice Bowl” of Kerala has turned into a “Den of Distress” . “If the farm ecology and economics, go wrong, nothing else will go right in agriculture”.(Swaminathan, M.S. 2007) To restore Kuttand to its initial pristine glory and vibrancy, steps should be initiated to restore the natural assets, initiate income generating activities and livelihood opportunities for a vast number of small farmers, landless labourers and fishermen. Restoring the eco- system, improved productivity, profitability and sustainability of small farms have to be accorded the highest priority

Though many farmers were following the conventional chemical based farming, a group of enterprising farmers had experimented with alternative farming systems, in which chemicals were not used. These farming systems were either rotational or integrated.

Objectives of Study

1. To study the viability of the new systems of farming which are being experimented in this Kuttanad.
2. To show the environmental superiority of the innovative farming systems
3. To discuss and explore measures to implement schemes for preserving the biodiversity of the region and enable people to earn a sustainable source of income.

Relevance of the Study

Kuttanad is battling with diverse problems which are the offshoots of the developmental efforts. This region is a testimony to the fact that tampering with the ecology and polluting the environment will negate and undermine the gains of improved agricultural output. The environmental degradation and the ecological disaster which this region is subjected to, substantiate the need to strike a balance between strategies meant for intensification of production and sustainable practices. The case study of this region enables us to discern the situation where for speedy development; countries are engaged in implementing projects and finding quick fix solutions to problems. It is disconcerting that these solutions themselves turn into problems in the form of environmental hazards and quite often irrevocable damages are inflicted, which can mar a country’s efforts to achieve sustainable development. The price paid for development strategies, which help to increase production may be a total disappearance of biodiversity and natural habitats. While it is accepted that enhancing food production is a matter of grave concern, especially in the context of food shortages and food inflation, the onus is on the present generation of farmers, scientists and other stakeholders of the society to invent a way of achieving the target of increased production without compromising on environmental security. The article brings out the conflicting priorities and plausible solutions for a greener, cleaner and prosperous future for Kuttanad based on the case study of a sample of farms and also secondary data. Many regions, the world over will have to take hard decisions on similar issues. The case study presented here enables us to understand the various dimensions of the problem and to explore the solutions. The solutions and suggestions can be replicated in other region with modifications.

The Study Area

The study area consisted of three Panchayats in Kuttanad out of a total of 64 Panchayats. The three Panchayats are Pallipad and Ramankari from Alapuzzha district and Kumarakom from Kottayam district. The reason for selecting these three panchayats was the fact that some farmers in these panchayats have been able to introduce innovations in paddy cultivation in order to make it more profitable. An analysis of the farming practices and the experiences of the farmers in the region help us in understanding the basic dynamics of the new practices followed in this region and how it can serve as a model for the other panchayats to follow. The study discusses how diversification to other uses like growing plantation crops or commercial purposes like hotel industry can be reversed and the farmers can be encouraged to diversify by starting allied and complimentary activities along with paddy farming to increase profits. Diversification to other crops like coconut, cocoa, rubber is harmful to the Wetland System of Kuttanad. It can lead to problems in drainage, water level tables etc. The land in this region is best suited for rice cultivation. Hence the innovative systems of farming like fish-paddy rotation or integrated farming which means simultaneous conduct of paddy cultivation, fish, poultry, and livestock can be profitably practiced in this region. Besides, the case for introducing these innovative systems become stronger since they use less fertilizers and pesticides and hence are less harmful for the environment. Kuttanad has an area of 1, 10,000 hectares which is divided into 4 ecological zones. The area of Garden or dry land is 31000 ha, Wetland 11000ha and reclaimed land situated below sea level, 55000 ha and water bodies including lakes, canals etc. 13000ha. It is divided into six agro-ecological zones (The Report of Kuttanad Enquiry Commission- 1971).

The name Kuttanad denotes the low-lying lands measuring approximately 25 kms east-west and 60 kms north-south on the west coast of Kerala. It is separated from the Arabian Sea by a narrow strip of land. The National Highway 47 runs along this coastal strip. Allappuzha, a minor port town is on its western fringe and the towns of Kottayam and Changanacherry are on its eastern side. Kuttanad lies between latitude 90 8' and 90 52' and longitude 760 19' and 760 44'. The region comprises the revenue taluks of Kuttanad and Ambalapuzha and parts of Karthikappally, Shertallai, Mavelikara, Chengannur and Thiruvalla taluks of Allapuzha district and parts of Changanacherry, Kottayam and Vaikom taluks of Kottayam district. The temperature of Kuttanad region varies between 210 C and 360 C. Humidity is very high in this area. The annual rainfall averages 325 cm. The rainy seasons are from June to August (South West Monsoon) and October – November (North-East Monsoon). The big expanse of water in this area is known as Vembanad Lake extending from Allapuzha to Kochi. The area of the lake is about 80 sq. km. Water in the lake is saline except during the monsoon season, when the flood waters keep the surface water sweet. The rivers Achenkoil, Pamba, Manimala and Meenachil discharge their waters into Kuttanad region from the south and east. These rivers after flowing through a network of channels and canals join the Vembanad Lake. This incessant inflow of silt carried by the rivers accumulated in this shallow bay and over a period of time, the region became an extensive brackish water lagoon and backwater system. In the course of time, the shallow parts of the lagoon further silted up by the river system became wetlands and the deeper parts remained as backwater. Cultivation is conducted in the wetlands. It came to be referred to as the Kuttanad Wetland System (KWS). The rice fields to a large extent were reclaimed from the backwaters.

Kuttanad has an area of about 870 sq. km. There are about 290 sq.km. of garden land distributed in this area. This part is one or two meters above the water level. The garden land is mainly used for coconut cultivation and human habitation. The rest of the area is below the water level. The soil is predominantly clay or silty clay. The watery waste has been progressively converted into rice fields by a process of reclamation and by construction of bunds around the fields leaving water courses for navigation, drainage and irrigation. The fields are at a depth of 0.5 to 2 meters below the mean sea level. There are nearly 52,000 hectares of rice fields in this area.The

Principal crops in Kuttanad are rice and coconut. The other regions in Kerala where rice is cultivated are mainly Palakkad and Trissur.

Compared to other paddy growing areas in Kerala, paddy cultivation in Kuttanad region has certain unique characteristics. Paddy lands in this region are divided into contiguous blocks called ‘Padasekharams’ or ‘Polders’ bound by waterways, rivers and other natural partitions. Many of the ‘Padasekharams’ are manmade since they are reclaimed lands from the bed of backwaters. The size of Padasekharam ranges from less than one acre to more than 1000 acres. There are more than 1231 Padasekharams in this area. The Puncha crop (Rabi or summer crop) is the traditional crop in Kuttanad during which 80% of the paddy fields are sown. The season begins from October-November when the operation of bailing out water from the padasekharam starts. The crop is harvested in March. The other season is the Virippu season (Varsha/autumn crop) in which 40% of the paddy fields is cultivated. The season starts in April-May and harvesting is done in August-September. This season is not preferred by farmers due to problems created by heavy rains, flooding and salinity. The density of population is 450 / km2.

Nearly 50% of the Kuttanad Wetland System is shared by Allapuzha district, 30% by the Kottayam district and the remaining 13% of the Pathanamthita district. The KWS has a total of 64 Panchayats.The Study Area which consists of the three Panchayats in Kuttanad region viz. Kumarakon, Ramankari and Pallipad located between 90 8’ to 90 52’ north latitudes and 760 19’ to 760 44’ east longitudes(The Kuttanad Development Project-1974).

The Biological Diversity of Kuttanad

The endemic flora and fauna of the region is a very significant ecological character of the wetland The large water expanse and the unique intermixing of saline and freshwater make Vembanad estuary an interface between land and sea and between saline and fresh water. This area is a repository of migratory birds and fishes. The brackish water environments promote a rich variety of mangroves and provide ideal habitats for diverse flora and fauna. Rare mangrove species such as *Excoecaria agallocha, Bruguiera sexangula* are reported to be found in this region((Swaminathan,M.S.et.al-2007).The fish species also change with the widely fluctuating salinity conditions of the Kuttanad Wetland System(KWS). During summer season fish varieties adapted to increased salinity conditions are found and during the monsoons fresh water species dominate. The lake is also home to a number of migratory and predatory birds and they depend on the lake for their survival.KWS is an ideal habitat for a variety of fishes like finfish, shellfish, and prawns and shrimps. The estuarine zone plays an important role in the life cycle of many shrimp species. The lake has rich sources of clam resources, live and sub- fossil deposits. More than 20,000 waterfowls visit this place during winter. Endangered species of water fowl that have been spotted are oriental darter, spot billed pelican, water cock and black billed tern(Swaminathan,M.S. -2007) .There is a close link between the ecological character and local livelihoods. The ecology has been providing livelihood opportunities in the form of inland fisheries, paddy, coconut and other allied activities. The canal network and the vibrant water transportation helped to build a flourishing economy since ancient times.

Over a period of time, the changing socio- cultural traditions, demographic pressures and the challenge of development have resulted in changing the ecological character of Kuttanad and at present the state of this region is a matter of serious concern.

Declining Area under paddy Cultivation

Besides environmental degradation paddy cultivation also suffered setbacks due to the following reasons

- Non-availability of labor
- Small uneconomic size of land holdings and excessive fragmentation
- Increased cost of inputs including labor charges
- The change in attitude of the new generation of farmers who either seek white collar jobs or migrate to Gulf countries
- High incidence of crop failures
- Lack of proper marketing system
- Insufficient research and extension services
- Increased trade union militancy

The falling profitability of paddy cultivation and the environmental degradation prompted some enterprising farmers to try out a number of innovative farming practices. The following case study brings out the possibilities of successfully adopting these farming systems. These farming systems enabled the farmers to earn more profits as compared to the conventional farming systems. Moreover, they have used all organic inputs, which are not harmful to the environment.

Case Study in Innovative Farming Practices

Study of Integrated & Rotational Farming in Kuttanad in Kerala (2005-06)

A study was conducted on the prospects of integrated farming systems practiced in Kuttanad in Kerala, which is the "Rice Bowl" of the state for the year 2005-06, taking the farmers from three panchayats for a comparative study of the feasibility and environmental effects of various types of farming. (Rajalakshmy-2010) A sample of 300 farmers from the 3 panchayats was selected. The farmers selected belonged to different categories like marginal, small, medium and large.. A group of farmers have adopted integrated farming practices and others rotational cultivation practices whereas the others continued to practice chemical based conventional farming practices. The integrated farming systems are the first step to organic farming practices since the farming practices are regenerative and complementary and drastically reduce the dependence on chemical fertilizers and pesticides.

The Innovative farming Systems and benefits

The integrated farming system refers to the conduct of all activities like livestock, fishery and poultry along with paddy without altering the physiography of the rice eco- system. These practices are mutually dependent. The wastes from the livestock, fishery etc can be used as manure for the crops. Thus the dependence on chemical fertilizers will reduce, which will enable cost reduction. This process is also environment friendly, which is relevant since environmental pollution has become a serious concern for the inhabitants of the region. Another farming system practiced in the region refers to rotational or sequential farming. In this system once the rice cultivation is over, the same fields are used for growing fish. The fish feeds on wastes like straw. Growing prawns, carp and other fish varieties have proved to be profitable. The residue from the fish culture makes the soil richer for the rice crop. A significant saving in the fertilizer cost is the advantage. It was also found that the weeding costs can be reduced since the rice-fish rotation was found to be effective in suppressing weeds.

Profitability of Innovative Farming systems Compared to Traditional Systems

To compare the profitability of integrated and sequential farming with the conventional chemical based farming, the data pertaining to the different categories of farmers was collected by stratified purposive sampling. The data pertaining to the farming operations, input costs, labour costs and machine costs were collected. The costs and yield comparison was carried out with the help of One Way Anova and the result clearly brought out the superiority of the integrated and rotational farming as compared to traditional farming . The table 1 and 2 and the diagram 1 substantiates the economic viability of these integrated farming practices.

Table - 1

Net Profit per Acre

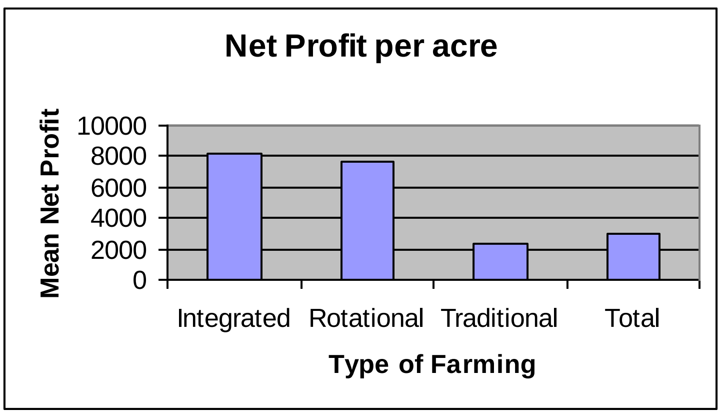
Item	Type of Farming	No. of Farms	Mean	Standard Deviation
Net Profit. per acre	Integrated	15	8139.8667	869.40981
	Rotational	18	7648.0833	1527.69065
	Traditional	267	2333.2174	1165.42032
	Total	300	2942.4418	2096.67008

(The mean difference is significant at the 0.05 level)

Table 2 ANOVA

Item	Groups	Sum of Squares	df	Mean of squares	F	Sig
Net Profit per acre	Between Groups	902871710.548	2	451435855.274	325.792	.000
	Within Groups	411539887.590	297	1385656.187	-	-
	Total	1314411598.137	299	-	-	-

Diagram 1



The next step is to study the environmental problems created by the chemical based farming in Kuttanad and how the integrated and sequential farming practices score in environmental superiority. A number of factors precipitated the ecological decay and environmental pollution of Kuttanad, which is renowned not only for rice cultivation but also for its natural beauty, and is a favorite tourist destination. According to M.S. Swaminathan, the region is suffering from 'ecological fatigue'. The basic cause of the ecological distress is that Kuttanad's development agenda came into conflict with its ecology. The ensuing paragraphs bring out the havoc played by the Green Revolution technology and other development schemes and how the integrated farming system is superior in terms of protecting the environment.

Environmental Consequences of the New Agricultural Strategies in Kuttanad

Intensive Cultivation versus Environmental Concerns

It is a fact that any tampering with the environment and ecology can lead to a number of problems. Any effort which leads to interferences with the ecology can create disturbances throughout the system. For example, the cutting of trees on the upper slopes of the Western Ghats affects the lowlands up to more than 100 km downstream by causing salinity intrusion during the summer. (Narayan. N.C.-1998) It has been experienced that the environmental deterioration of the Kuttanad eco-system has resulted from intensive monocropping of rice. There are two issues involved here. Since rice cultivation has become expensive, many farmers started converting the paddy fields into more profitable uses like coconut and garden crops which require more dry land environments. Such activity alters the ecology and leads to environmental problems. It is evident that there is a dichotomy between environmental needs and economic priorities. The conversion is justified or opposed by different groups of people. The paddy cultivators are of the view that they are not bound to fulfill a social obligation at the cost of their own profit or even survival. The agricultural labourers vehemently argue that attrition of paddy lands will reduce their job opportunities and thereby their livelihood itself is in danger. The environmentalists are of the opinion that conversion of paddy land will be detrimental to ecological balance and should be arrested immediately. It is argued that conversion to the crops for other purposes should not be allowed since any reduction in the traditional paddy area will naturally lead to a situation of increasing food deficit from the present precarious level. The actual conversion has been mainly to perennial crops, followed by annual or seasonal crops and a small percentage to non-agricultural uses. Each type of conversion has its own repercussions. Some of the conversions involve irrevocable changes in land use while others can be reversed. Any type of filling or raising the level will definitely interfere with the hydrological systems, especially flood control functions of the wetland. It may also disturb the drainage pattern and cause water logging. Conversion to other crops, without irreversible changes in land is a lesser evil. But even this could upset some of the hydrological functions of the paddy fields.

(Government of Kerala Report- 1999) For other crops, water logging should be avoided. The farmers will be encouraged to drain the water from the fields. This reduces the duration of water retention in the field and hence reduces water percolation also. This could result in insufficient recharging of the ground water regime and might create water scarcity in the region in marginal cases. Mining for clay not only disfigures the landscape but is also hazardous to life. It is opined that the opening of a clay mine in the middle of the polder will drive the neighboring farmers to frustration and cause abandonment of their cultivation and eventually sell out. A holistic solution to the situation has to be found. It is essential to consider the implications of the situation with an impartial outlook and the government should create policies to protect the interests and welfare of all the people, irrespective of political, social or cultural segmentation.

Impact of Engineering Structures on the Agri-Ecosystem

Another major developmental effort which has affected the environment adversely is the building of the engineering structures. The new agricultural strategy and the building of the engineering structures i.e. the Thannermukkom salt water Barrier and the spillway at Thottapally were the major interventions in the Kuttanad natural system. Almost all the state sponsored development programmes in Kuttanad which were meant to boost rice production exacted a toll on the ecosystem. A major environmental impact is the shrinkage of the backwater area due to the land reclamation into polders for cultivation. The spillway which started functioning in 1955 for the speedy drainage of floodwaters to the sea was found ineffective due to faulty design. (Government of Kerala Report-1999) It was supposed to drain 64000 m3/sec of floodwater coming from the highlands through the four rivers to the sea, but less than 20,000 m3/sec of water pass through it. In the beginning before the spillway was constructed, these waters used to go to the Cochin estuary and flood the low lying rice fields. But when it was confined to flow through the spillway, flooding began to occur in the immediate vicinity. Another unintended consequence is the accretion of sand from the sea near the shutters of the spillway, which prevents water flow towards the sea. There were a number of technical and organizational lapses in construction of the spillway. Insufficient knowledge about the natural processes and faulty design led to ineffective functioning of the spillway. Similarly the salinity barrier commissioned in 1972 to prevent salt water into the Kuttanad system during summer was supposed to facilitate double cropping of rice. But it led to the disappearance of several fish species (Swaminathan

M.S.et al-2007) The backwater systems of Kerala coast and the estuaries function as nurseries of various species of marine shrimp. The construction of the regulator led to a reduction in the backwater area available for the prawns to spend their larval and growing stages of life. The prevention of the inflow of saline water into the lake during summer has led to the decline or disappearance of several fish species that grow in saline water. The decreased fish breeding adversely affected the livelihood opportunities of fishermen who form a sizeable section of the population. Toddy tapping from coconut trees which is another source of livelihood was adversely affected by the salinity barrier. Coir processing was also seriously affected, an industry in which 95% are women. Before the salinity barrier was put up, the annual ingress of saline water to the upper reaches of Kuttanad during the summer months helped to check the growth of many of the water weeds. The complete prevention of saline water ingress after the salt water barrier was constructed accelerated the growth of weeds like salvinia. The profuse growth of water weeds caused problems to rice cultivation and inland navigation besides adversely affecting the mangroves on the bank of the lake. The closure of the barrier resulted in stagnation of water causing a decline in the growth of lime shells. The growth rate of the black clam which is major resource for the lime shell fishery is adversely affected by a rapid decline in salinity. The salinity barrier led to problems like proliferation of weeds, stagnant water, mosquitoes, poisonous snakes and difficulties in navigation. These were some of the consequences of drastically intervening in nature's processes..

Green Revolution Strategies and long term Implications

The Green Revolution strategies were implemented in Kuttanad through a policy of heavy subsidies to promote High Yielding Variety seeds. This is turn necessitated intensive use of fertilizers and pesticides. The engineering structures to prevent salinity and check the flow of water were introduced with the aim of enabling double cropping. The farmers were not disciplined and this led to the staggering of the crop season after the salinity bar was put up. This affected the natural balance of the system. The productivity increased to a very high level after the fertilizer application began. But once applied, fertilizer application is an irreversible activity (Narayan N.C.- 1998) Once the farmers got used to applying pesticides they were too scared to attempt cultivation without fertilizers and pesticides. Many of the farmers did not have the requisite knowledge and experience to carry out scientific application of pesticides. If the pesticide application is not done properly, the pests become resistant to pesticides. Increased application of fertilizers and pesticides and stagnant water led to increased pollution. The tidal flow which used to flush the water body is completely prevented by the closure of the salt water barrier. Consequently, the water drained off from the rice fields containing large amounts of pesticide and fertilizer residue remains stagnant. This leads to increase in fish mortality. Besides agricultural wastes the water is contaminated with industrial wastes, urban wastes, coir retting, acidity and dredging for lime shells. The estuary also receives large quantities of sewage from the urban and semi-urban townships. Besides the pollutants, a lot of human and animal wastes which go into the system due to lack of sewage facilities makes the environmental pollution worse. This was responsible for the spread of diseases like dermatitis, jaundice, colitis, and amoebic dysentery. In this manner, the developmental efforts and the new agricultural strategy have played havoc with the fragile balance of the natural system.

The Role of Innovative Farming Practices in Reducing Environmental Pollution.

Arresting the Disruption of Ecological Balance and Biodiversity

The results of a number of experiments conducted in the Regional Agricultural Research Station (RARS) brought out the environmental superiority of the innovative systems over conventional rice farming. According to Kerala Agricultural University, such a regenerative farming strategy that blends different farming practices through biological diversification and nutrient recycling is most relevant to the wetlands of Kerala where escalation in costs of production and environmental degradation have become a matter of major concern. The environmental superiority of the new farming techniques is that there is no use of pesticides at all. The use of pesticides is detrimental to the fish farming and poultry. However, many farmers find it difficult to escape from the vicious circle of pesticide application. This situation has risen from the interrelated and complex nature of the eco-system in which destruction of one organism in the chain can disrupt the entire eco-milieu. The destruction of frogs led to reduction of rat snakes. The rat population increased which was a detrimental to the rice. To control the rat population, pesticides had to be used, which was harmful for the fish, earthworms etc. Hence, integrated and rotational farming methods will pave the way for adopting organic farming methods.

Scientific Superiority of Integrated and Rotational Farming Practices

The environmental superiority of the integrated farming system over the conventional farming was proved through a series of experiments conducted by the Regional Agricultural Station, Kumarakom(Padmakumar, K.G.-1997) The critical environmental parameters in rice-fish integrated systems such as pH, dissolved oxygen and salinity were found to be favourably supportive of high gross primary productivity. This resulted in higher fish yields. Experiments conducted on trial basis proved that GPP (Gross Primary Productivity) is the highest under poultry-fish rice integrated system, followed by rice-fish. Multi-tier integration with rice, fish, poultry, pigs and cattle led to organic enrichment. Such systems were found able to sustain high biomass production compared to non-integrated systems. The high dissolved oxygen levels (DO) observed in the integrated systems implied that the organic additions were continuously utilized for biological production. The high dissolved oxygen level was due to photosynthetic production of phytoplankton. Also the high sediment organic carbon content in the integrated system as compared to the non-integrated rice fields indicated the beneficial effects of organic enrichment of the system

Table 3

Environmental Variable in the rice-fish integrated system

pH	7.00
Free Carbon Dioxide	3.8 PPM
Dissolved Oxygen (DO)	9.66 PPM
Turbidity	72 cm
Nitrite (NO2-N)	40 M at /1
Nitrate (NO3 -N)	20 M at /1
Phosphate (PO4 – P)	10 M at/1
Phytoplankton	8.16 X 10^5 cells /litre
Zoo-plankton	9 X 10^5 cells / litre

Source – Padmanabhan et. al 1998

It was found that the nutrient concentrates in the open water and conventional paddy fields in adjoining areas were perceptibly lower than fields under the integrated system. The Phosphate concentration was 10 mg/litre in the integrated system as compared to 0.4 to 1.4 in the open water systems. The Nitrate concentrates were only 1 to 1.3 Mg/ litre and nitrites only in traces. The phytoplankton density was 8.16 X 10.5 cells/litre in the integrated system whereas it was only 0.9 X 10^5 cells /litre in the open water system

Table 4

Manure conversion equivalence in the rice-fish-piggery-poultry integrated system in Model farm – Pazhaya Kayal

Source of manure	No. of units	Period of Rearing	Manure Input Dung/ Dropping Dry wt.(kg)	Organic matter (kg)	Nutrient equivalent (kg)		
					N	P	K
Piggery	23	12 months	Solid – 23000	4140	143	131	96.6
			Liquid – 27600		110	30	124.2
Poultry	6000	6 months	15000	3825	244.5	231	127.5
Straw	7.2 ha		25100	-	301.2	50.2	125.5

Source – Padmanabham et. al. -1998, RARS – 1998

Manure conversion equivalence of the different items in the integrated system in the model farm is given in Table 4. The extent of nutrient enrichment is represented by the NPK equivalence. The Manure Conversion Factor (MCF) which measures the manure use efficiency for pig dung was reported to be 2.17 to 5.77. This implies that 2 to 6 kg of pig dung can produce 1 kg of fish. Similarly the MCF of chicken manure was found to be 2.28 to 5.48. Moreover, enhanced soil fertility resulted from contribution from detritus including bacterial load. According to Yang (1994) the bacteria load for a pig-manure pond is 4.15×10^{6} individuals/ml. However, in the rice-fish system, which is popularly practiced in Kuttanad, only the integration of straw is facilitated and hence organic enrichment is comparatively reduced than in the multi-tier integrated system involving crop, livestock and fish. Factors like the existence of the mineralized plant nutrients, the contributions of the detritus and bacteria are the most important nutrient sources which facilitate high and spontaneous secondary fish production in the integrated system.

Table 5

Composition of animal manure commonly used in integrated farming systems

Composition	**Dung**	**Urine**	**Mixture**
Pig manure			
Moisture	85	97	72.5
Organic Matter	15	2.5	25
N	0.50 - 0.60	0.30 - 0.50	0.45
P (P_2O_2)	0.45 - 0.60	0.07 - 0.15	0.19
K (K_2O)	0.33 - 0.50	0.20 - 0.70	0.60
Cow manure			
Moisture	80.85	92.95	77.5
Organic Matter	16.4	2.3	20.3
N	0.30 - 0.45	0.63 - 1.20	0.34
P (P_2O_2)	0.15 - 0.25		0.16
K (K_2O)	0.05 - 0.15	1.30 - 1.40	0.40
Poultry manure	**Chicken**	**Duck**	**Goose**
Moisture	50.5	56.6	77.1
Organic Matter	25.5	26.2	23.4

N	1.63	1.10	0.55
P (P_2O_2)	1.54	1.40	0.50
K (K_2O)	0.85	0.63	0.95

Source – Padmakumar et. al

The composition of different types of animal manure in integrated farming is given in the table 5. These different systems of integrated farming have been experimented in Kuttanad. Hence, scientific evidence proves the ecological benefits of integrated farming systems in the Kuttanad Paddy fields.

However there are a number of problems in implementing the innovative environment friendly farming practices like organizational problems, small size of the average farms, paucity of funds and labor problems. It is very essential to initiate some urgent measures to save Kuttanad from further degradation which will impact adversely on the lives of the people in the area. With its various advantages like highly fertile land, agriculture should have flourished as in olden days. It is imperative to find a viable solution on how to carry out farming profitably, without disturbing the ecology. Since the average size of farms is small, the most pragmatic policy would be farming on a co-operative basis. Earlier experiments in the same lines may have failed. Fish cultivation on a co-operative basis seemed a good idea and would have transformed the lives of the poor people. But the scheme did not work for lack of co-ordination, leadership and most importantly lack of finance to buy fish seeds. Leadership and organization are very important. In fact, the Polder Committees can undertake this responsibility, with the support from the Government, NGOs,research institutions and scientists. Information, training, technical and financial support are crucial for the success of such a venture. For the small farmers it is an uphill task. The Union Government had entrusted Dr. M.S. Swaminathan Research Foundation to conduct a study of this region and an amount of Rs. 1840 crores was sanctioned under the package for the eco friendly development three years ago. The authorities have to yet to implement the measures to mitigate the problems faced by the farmers and other inhabitants.

Protection and ecological restoration of the water spread area, improvement of infrastructure pollution control by creating local waste treatment, regulation of floodwater, removal aquatic weeds, measures to augment bio- diversity, research and extension facilities for enhancing rice and fish production will enable Kuttanad to regain its coveted reputation of the 'Rice Bowl' of Kerala

Conclusions

It is imperative to take some urgent measures to restore the ecological balance of Kuttanad and control the rampant pollution, which are the offshoots of developmental strategies and policies intended to increase paddy production. While it is essential to increase productivity it is equally important to do so through sustainable methods. Empirical evidence has proved the superiority of innovative farming practices, which are being practiced by some enterprising farmers in Kuttanad. The scientific superiority of these farming practices has been proved. What is actually needed to make this region vibrant, productive and healthy is to ensure that such farming practices are adopted by the other farmers too. There is a dire need to organize the small and marginal farmers and conduct farming on co-operative lines. Effective leadership and co-ordination can be provided by the Polder Committees. The farmers have to be assisted financially. Soil testing, improved methods of farming, mechanization, facilities for storage and marketing and flood control are the important steps to ensure the success of innovative farming practices. The package for restoration of the ecological balance of Kuttanad has to be implemented in its true spirit if Kuttanad is to regain its reputation as the "Rice Bowl" of Kerala.

References

1. 1 .Padmakumar, K.G. (1997) Rice-Fish Rotational Farming in the Wetlands of Kuttanad Region, Report prepared for FFDA, Kottayam, Kumarakom ,RARS

2. Prabhu, M.J (2007) Reducing Input Costs , *The Hindu, Survey of Indian Agriculture, Chennai*, pp. 121-125 Prasad, C.S, (2006) *Sixty Years of Indian Agriculture*, New Century Publication, New Delhi

3. Narayan, N.C. (1998) Against the Grain, Institute of Social Sciences, Hague, Netherlands.

4. Rajalakshmy. G.(2010) Emerging Issues of Diversification and Profitability of Land Use Patterns in Kerala, Project Report for PhD ,YCMOU ,Nashik

5. Ram. B. (2003) Impact of Human Activities on Land Use Changes in Arid Rajasthan: Retrospect and Prospects. In*: Human Impact on Desert Environments*, Ed P. Narain,.S

6. Sud, Surinder (2008) Area Under Organic Farming Expands Sevenfold in Five Years, *Business Standard, Mumbai 8thDec*, P 3

7. Swaminathan,M.S.(2007) Agriculture Cannot Wait, New Horizons in Indian Agriculture, National Academy of Agricultural Sciences, New Delhi

8. Swaminathan,M.S.et al ((2007). Measures to Mitigate Agrarian Distress in Alappuzha and Kuttanad Wetland Systems; *A Study Report by Swaminathan Research Foundation, Union Ministry of Agriculture.*

9. The Report of Kuttanad Enquiry Commission (1971) Thiruvananthapuram, Government of Kerala

10. The Kuttanad Development Project(1974), Thiruvananthapuram, Government of Kerala

11. The Report of the Expert Committee on Paddy Cultivation(1999) vol.1, Main Report, Thiruvananthapuram, Government of Kerala.

12. The World Bank (2004) Agriculture Investment Source Book, *Agriculture and* R*ural Development- Organic Agricultural Production System*, pp 179- 181

Digital References

1. India; The World Bank (2006) , ' *Priorities for Agriculture and Rural Development'* http://www.WorldBank.Org

2. John.A. Bierbaum, Department of Horticulture, Michigan State University, http; // www.ing.in/agriculture/ agricultural best practices/ organic production/ organic agriculture- principles and practices

3. Kuttor Radhakrishnan(2011), 'Poor Implementation of Kuttanad Package Scheme, http: //www.thehindu.com.

4. Mahidi,Ebrahimi (2007) " *Why should India Promote Organic Farming* ", http://www.organicfacts

Terms & Concepts Used

1. Integrated Farming- In this farming system, which is also known as simultaneous farming system, rice cultivation is conducted along with fish, poultry, pig, and livestock. The major biological feature of this system from a nutrient flow point of view is by-product recycling with diminished reliance on agro-industrial inputs and thus regenerative farming practices are followed.
2. Kuttanad Wetland System- KWS is a part of the Vembanad Wetland System, which is a part of the large estuary stretching from Kayamkulam Kayal(lake)in South to Cochin in North , where it meets the sea. It is a floodplain of four rivers. These rivers confluence into the Vembanad Lake and then travel further to North towards Cochin and empty into the Arabian Sea.
3. Padasekharams or polders- Contiguous cultivation in Kuttanad is practiced in blocks of farms called Padasekharams or Polders. The polders are reclaimed from the lakearea and have an outer bund or boundary, which is a raised portion and which separates the polders from the lake.
4. Panchayat- Local self Governments of the villages and small towns in India.
5. Puncha crop (Summer crop)- Season starts in November –December and ends in April-May. This is essentially an irrigated crop and is the best time for paddy cultivation with lots of sunshine.
6. Reclamation- The process of recovery of land from water. The reclamation of Kuttanad farms was difficult, which involved the diversion of the course of the river, which was 30 ft. deep at that point. A barrier was erected across the river and a bund was constructed with whole stems of coconut tree and cemented with garbage, river sand and clay.

7. Rotational farming System- In this, Fish/prawns are cultured in rice fields between rice crops. The residues from the fish culture makes the soil richer for the rice crop , while the residues from the rice crop such as rice stubble, encourage growth of fish.
8. The Vembanad Lake- This lake mreasures about 13,000 hectares and has several species of fishes, crabs, clams. This huge lake separates the paddy fields from the sea in Kuttanad. The lake opens out to sea.
9. Virippu(kharif/ Autum)- This cultivation starts by mid April.The South West monsoon helps the growth of paddy and the harvesting is done in August- September

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