Chapter I

INTRODUCTION

With rapid increase in population and an extractive system of natural resource utilization, coastal wetland ecosystems are subject to a variety of pressures compatible and incompatible with its ecology. The coastal lowlands that occupy about 1.2% of the geographical area are thus exposed to persistent pressures and intersectoral conflicts. These contradictions are exacerbated by rapid reclamation of coastal lowlands for agriculture, urban development, and more recently aquaculture. This situation calls for a common language for sharing of resources. Despite enormous expenditure and effort for infrastructure development, there is a thinking that the Green Revolution technology that has significantly increased food production in irrigated rice ecosystems; has not commensurately benefited the farmers in coastal rice lands. This calls for new approaches for food production and income generation in these areas.

Although India occupies just 2.2 percent of the global geographic area, the land supports over 17 percent of the global population and over 15 percent of the livestock. Despite the fact
has increased from 50MT in 1950 to 208 MT in 1999, 30 percent of the population live below poverty line with an income less than 1$ per day.

In a recent study by the International Food Policy Research Institute, in the next two decades, the demand for cereals globally is projected to increase by 41 percent and animal protein by 63 percent (Anon. 1997). It is also inferred that food production is unlikely to keep pace with the jump in demand leading to a doubling of 'food gap' i.e. the difference between production and demand. In such a situation as many as 150 million children in developing countries i.e. one out of four preschool children would be malnourished in 2020 AD. It is in this context that production strategies need to be visualized and organized. Essentially we need technologies that cut costs on production so that the food is produced at cheaper cost affordable to the poor.

A critical look on the state of art revealed that a 'piecemeal' approach to research and development giving emphasis to commodity or 'commodity-centric' approach is the cause of the crisis. It is against this background that the concept of sustainable integrated farming gains relevance. Fairly recent lines of scientific enquiry, such as farming system concept (Norman, 1980) and agro ecosystems concept (Conway, 1985) provide theoretical framework for this thinking. The agro ecosystem concept goes beyond soil
types to define land types, while FSR introduces the perception of farmer participation as a major variation from the commodity-centric approach to development.

Since farming is the biological process of transformation of solar energy into biomass involving major resources, land and water, a resource based approach that facilitates scientific and optimal utilization of production potential of natural and human resources is the primary consideration of this concept. Full utilization of production potential through intensification and diversification will not only provide income and employment opportunities but will also ensure livelihood security to the people who subsist on them.

Although Kerala is the first state that has successfully implemented land reforms thereby transferring land ownerships to the tenants, this was not followed by a technological revolution to facilitate the viability of these small holdings. It is estimated that 98% of the farmed land is comprised of small holdings less than two ha. It is well known that the income from cropping alone in such small and marginal farms is hardly sufficient to sustain the family. Therefore, in order to assure a decent living, one has to think of farm enterprises that would complement this cropping activity; a judicious mix of one or more enterprises that can recycle residues, and crop wastes need to be identified for every situation,
based on the cardinal principle of minimizing competition and ensuring complementarity. Water being the most valuable resource in the wetlands, a farming system that integrates fish culture along with rice is a suitable strategy to ensure efficient utilization of resources.

Kerala, a narrow strip of land at the southern tip of the Indian sub-continent is a unique land formation wedged between the Western Ghats and the Arabian Sea. It is one of the smallest states of the Indian union with an area of 38863 sq.kilometres, which is about 1.18 % of the total land area of the Indian union; however the state holds 3.38 % of the population of the country. The land formation is divided into three distinct regions; the highlands which is above 75 m above msl high, the midlands which is between 7.5 and 75 m above mean sea level (msl) and the lowlands which is below 7.5 m above msl. Due to its location on the western slopes of the Western Ghats, which is the windward side of the southwest monsoons, Kerala receives an average annual rainfall of 2800 mm.

Kerala is fed by 44 rivers, of which 41 flow westwards from the hills and drain themselves into the Arabian Sea. The narrowness of the state and the hill formations on the eastern side cause the rivers to tumble down rapidly carrying organically rich silt from the forested upper reaches down into the low lying areas.
The Western Ghats form part of the evergreen tropical forests covering vast tracts of the southern peninsula. These forests play a vital role in water retention of the area. The low lying wetlands play an even more important role in the retention of water. The Western Ghats forms the catchment area of all 44 rivers in the state. The highlands are generally thickly forested in the upper reaches, while in the lower ranges, the forests are interspersed with plantations. On the western fringe of the state are the lowlands and the coastal zone containing a string of estuaries and backwaters. Invariably all the rivers are dependent on the forests for a sustained flow. With its rugged topography and heavy rainfall and also the prolonged duration of the flow, the wetlands play an equally or more important role as receptacles of floodwaters and for recharge ground water.

The lowlands are densely populated and contain some of the earliest settlements in the state. The wetlands (or nilams) in Kerala have been drained and utilized for agriculture and human settlement from ancient times. Paddy is mainly cultivated on the plains of the lowlands and the valleys of the highlands and midlands. In each of these locations, the paddy fields or wetlands play a unique ecological function. The rice agro eco-systems of Kerala are mainly confined to valley bottom areas of the midlands
and below sea level situations in the coastal low land; Kuttanad, Kole, Pokkali and Kaipad rice tracks.

**Kuttanad: Features.**

Kuttanad forms an ill-defined low-lying area in south central Kerala with an intricate system of canals, rivers and backwaters. It forms the deltaic region of four medium rivers; Pampa, Achencoil, Manimala and Meenachil and remains waterlogged almost throughout the year. Together, these rivers discharge huge volumes of water and carry with them heavy deposits of organically rich silt, which in earlier times used to be evenly distributed in the padashekharams in the course of the annual flooding. With the cessation of the monsoons, Kuttanad is thus left a recharged, replenished and fertile land most ideally suited for rice cultivation. After the flooding, the excess water is slowly discharged into the Vembanadu Lake, the largest brackish water body in southern India. The Vembanadu Lake is connected to the Arabian Sea, which brings in tidal influence and seasonal salinity into the system, a large part of which is below sea level. Annual flooding and seasonal purification by saline intrusion from the brackish Vembanad Lake has made Kuttanad an ideal location for rice cultivation from ancient times.

Being in confluence with the Arabian Sea, through the Vembanad lake, these wetlands have also been important for fish
production and have been the nursery and breeding ground of a variety of coastal fish/prawn species in addition to a resident population of freshwater fishes. Thus the greater Kuttanad region lying between lat. $9^\circ 8'$ and $9^\circ 52'$ N and long. $76^\circ 44'$ E in the Indian peninsula lying largely 0.6 to 2.2 m below msl is a highly complex eco-system, unique in its topography and ecology. Kuttanad finds mention in the early Sangha poetics book *Tolkappiyam* as one of the twelve regions where ancient Tamil was spoken. The 11th century AD work of *Periya Puranam* also mentions Kuttanad as a distinct geographical region to the north of Kollam.

The region experiences a humid tropical climate with temperature showing variation between $21^\circ$ C and $34^\circ$ C. The mean relative humidity is 79%. The rainfall data recorded at Kumarakom during the past 10 years indicate an average rainfall of 2330 mm. A prolonged rainy season extending from May to November and a lean period from December to April are characteristic features of the weather in the area. The southwest monsoon contributes over 60% of the rainfall in the region. The existence of warm water and humid environmental conditions are congenial for rice cultivation in the deltaic region and fisheries has also been an important enterprise in the vast wetland water bodies.

Although, there is substantial homogeneity in the physical features of Kuttanad, there exists considerable heterogeneity within
the region with respect to agro-ecological conditions. The core area of Kuttanad region comprises of two deltaic formations, one at the confluence of the three river systems, viz. Achencoil, Pampa and Manimala and the other, of the Meenachil river. Both these deltaic formations gradually slope down to merge with the Vembanadu Lake. However, flood incidence and submergence during monsoons are different in the two different parts of this delta. The impact of flood incidence and submergence is at its maximum in areas close to the uplands, identified as “Upper Kuttanad” because of the non-availability of land to dissipate the floodwaters. The impact of floods is least experienced in areas adjoining the lake and backwaters since vast area is available to contain and spread out the floodwaters, and is distinguished as “Kayal Land”. The area in between is subject to moderate flood impacts and is identified as “Lower Kuttanad”.

Being away from the estuary and the backwater systems, upper Kuttanad is least affected by salinity, while “Kayal land” lying close is more vulnerable to salinity ingress. The deltaic formation of Meenachil river, mostly coming in Kottayam district, is separated by the Kayal lands and is subject to both flood submergence and saline water ingress. This area is known as “North Kuttanad”. On either side in the south and the north of these deltas, the low land is characterized by high acidity and
periodic salinity. These lands are called "Kari Lends"; Vechoor Kari (Vaikom) on the north, and the "Purakkadu Kari" (Ambalapuzha) on the south. The deltaic formation and the backwater systems are separated from the sea by a sand dune formation overlaid on silt and clay deposition and are identified as "Costal Kuttanad".

The ecology of Kuttanad is therefore influenced by a combination of floodwater and seawater entering the Vembanadu Lake, felt variedly in different regions of this tract. The incidence of saline and fresh water enables, the sustenance and survival of a diversity of aquatic life—both plant and animal. The extensive water surface in the lake and rivers provides a rich and favourable environment for fresh water and brackish water fish. The eastern shores of the lake also sustains a rich crop of lime shell supported by live clam beds and sub fossil shell deposits.

The wetlands of Kuttanad have a very significant role in the maintenance of the health of the eco-system of the area. The paddy fields provide a natural drainage path for floodwaters. The canal systems which connect the paddy fields would drain away the waters to the nearby waterways or estuaries, allowing the floods to dissipate and discharge freely and unhindered. Fields perform the natural function of providing flood plains for the rivers in spate. The paddy fields provide a very useful cushion in absorbing the fury of the floods. The most vital function of the
paddy fields is in the matter of recharging the ground water. Whereas most of the crops would fail if water were retained for a long time, paddy works just the other way round. The coastal wetlands thus form a significant part of the natural aquatic system. The seasonal salinity incursions in low-lying section and tidal influence also have helped to sustain a variety of marine and estuarine life.

Despite being a food deficit state since early days, people of the former generations developed a rice culture converging with the natural topography and rhythm of the area, whether it is the valley bottom rice land or midland or coastal low land. Hence in the midlands and the highlands, most configurations of the topography and water drainage zones were utilized for rice and were not converted into terraced rice cultivation as practiced in other parts of the world. Similarly in Kuttanad, unlike in other places where rice season starts with the onset of monsoon, the rice culture was developed with the cessation of monsoon; from September/October

Until the turn of the century, rice cultivation was done once in two years, with the land lying fallow every alternate year. The natural recharging of silt brought in by rivers through annual flooding was sufficient to provide sufficient yield. However, cultivation turned annual by the 1940s primarily due to higher demand for grains as population increased. Besides, the Central
government took food sufficiency as a national priority. Cultivation in Kuttanad was intensified into double cropping during 1950s to meet the increasing demand. Traditionally the rice crop in Kuttanad is called Punja extending from September /October to January/February raised in harmony with the natural environmental system. With the advent of double cropping, Virippu rice cultivation (Varshakrishi) also became prevalent in these tracts from April to August. The Punja lands of Kuttanad are divided into identifiable homogenous physical entities called padasekharams or polders, which are contiguous stretches of wetlands bound by an earthen bund and a water course. The padasekharams range in size from 2 hectares to nearly 1000 hectares and there are about 1100 such polders in Kuttanad. The Punja lands account for approximately 55000 ha., forming 80% of the wetlands of Kuttanad, classified as Karappadom, Kayal and Kari with reference to their elevation from the mean sea level and geological and soil characteristics.

Historically, Kuttanad is a densely populated area owing to the scope for multifarious economic activities like rice cultivation, fishing, coir making etc. Kuttanad is a low lying and water logged region, transformed into a vast sheet of water of varying depths during the monsoon season (Pillai and Panicker 1964), replenished by silt brought by the river systems, the area
was found to be well suited to rice cultivation from early days. The rice fields originally reclaimed from marshes or backwaters are transformed for cultivation by forming outer bunds. A sheet of water covers the agricultural land of Kuttanad when there is no cultivation and water is bailed out in the beginning of every cultivation season. Reclamation of land for cultivation and flood control used to be undertaken by private farmers, with assistance from the state during the early periods (Pillai and Panicker 1965). In course of time, Kuttanad became the rice bowl of the state and a rice centric economy evolved here, although fishing was also an important enterprise for people of the lower echelons of the society. Being in confluence with the Arabian Sea, lake Vembanad serves as an extensive nursery for marine prawns and also sustains a lucrative fishery. For centuries fishing has been an important occupation for the population of the area. Records of reclamation are available since 1834 when the government of Travancore advanced loans for reclamation and by the dawn of the twentieth century almost 2300 ha. of Vembanadu lake was reclaimed (GOK 1971). The initiative for institutional reforms came from the monarchy and by 1850 as a consequence of this policy, a major share of the cultivated land and the whole of the wasteland came under the state. This led to the emergence of a class of independent farmers who reclaimed the backwaters of Kuttanad for
rice cultivation through operations, which required large capital investments (Pillai and Panicker, 1965). The increasing pressure of population on land during the last century and the exhaustion of shallow backwaters for reclamation purposes compelled the people to venture into the deeper waters of the Vembanadu Lake. These are known as the "New Reclamations" (Pillai and Panicker, 1965) or the Kayal lands.

The state has constantly maintained a steady influence in the field of agricultural production especially in relation to rice cultivation. Almost all the state development interventions in Kuttanad were oriented towards turning it into a rice centric economy. The early reclamation of land from marshes and backwaters were under private initiatives with the active support of the state. Studies identified some pre conditions for double cropping in the region and two engineering structures were suggested; a spillway to drain off the floodwaters and a barrier to check the incursion of saline water. The salinity barrier was meant to limit the damage caused by the high spring tides in November and the saline intrusion in February/March. It was assumed that with these structures, the rice growing season could be effectively extended and the cropping intensity increased. Better water control was also expected to improve the yield. Construction of the spillway at Thottappally on the upstream of the lake on the
southern reaches began in 1951 and was completed in 1955. But the construction of the regulator at Thanneermukkom, the narrowest portion downstream the lake, which began in 1955, was delayed up to 1974 with only two thirds of the original length of 1402 metres completed (Kannan, 1979). However, the spillway, reported to have been designed after detailed hydrographic and hydrological studies, drained only less than one third of the desired capacity and the salt-water barrier, also proved to be a disaster (Kannan, 1979). Rice cultivation, traditionally systematized in tune with nature's rhythms (of monsoon floods and summer salinity) was disrupted with the above-mentioned engineering interventions. Staggering of the crop season and resultant lack of discipline in rice cultivation after the construction of the salinity barrier has further affected the natural balance of the system (KWBS, 1988).

In the 1960s, food self sufficiency was conceived as a national policy and the Government of India launched programmes like Integrated Agricultural District Programme (1960) and the Integrated Agricultural Area Programme (1963). These programmes were implemented in the form of packages of high input cultivation in selected locations in the country, which had the natural resource potential to enhance food production. Kuttanad was one of the two regions selected in Kerala for this “Green Revolution” strategy and the urgency for such a policy to embrace agricultural
modernization was stressed. The agro-ecological peculiarities that constrained cattle rearing, limiting the availability and conservation of organic manure, soil peculiarities, vulnerability to pests and diseases were all argued as characteristics of Kuttanad in particular that demanded the need for chemical fertilizers for high yielding varieties. (Pillai and Panicker, 1965). Massive use of fertilizers and pesticides, made possible through a policy of heavy subsidies, promoted the widespread use of high yielding variety (HYV) seeds more prone to pests and diseases, which in turn necessitated more intensive use of fertilizers and pesticides. This vicious cycle of cultivation has affected the Kuttanad eco-system immensely.

Although an integrated nutrient management comprising of organic manure coupled with chemical fertilizers was recommended for high yielding rice technology, the major constraint with the use of traditional manure like cow dung has been the cost of transportation and application. Traditional farmers were aware of the advantages of organic manure. The low tolerance of HYV to pests and diseases and non-judicious plant protection measures have further increased the incidence of pests. (John et.al.1993, Thomas et.al.1993; George and Krishnakumariammma, 1993). Diseases and consequent crop loss have become quite common (Aravindakshan, 1990; IIRD, 1978).
This has led to vicious cycles of pesticides-disease syndrome. Crops which were effectively protected with four to five treatments per season, had to be sprayed ten to fifteen times in subsequent years (Mohandas 1983). Pesticide use has affected the eco-milieu of Kuttanad quite seriously, especially after the widespread destruction of the frog population. This has serious consequences for pest control (IIRD, 1978; KSSP, 1978). Abraham (1980) gave a vivid description of the complex and inter-related nature of the ecosystem and suggested that the destruction of one organism in the chain can disrupt the entire eco milieu. Due to the destruction of frogs for example, rat snakes perished. This led to the proliferation of the rat population and was a big menace for rice spreading of rice pests demanded the use of pesticides which killed the fish, the remaining rat snakes, rice friendly pests and earthworms which enriched the soil were killed or driven away the birds that fed on the rice pests. This was followed by the drastic attacks of a new endemic pest (munja), which forced the farmers to go in for more intense application of pesticides (Abraham 1980).

A major problem faced by the cultivators in raising the second crop of rice was the flooding of the fields due to breaches in the temporary bunds. The state government drew up a scheme to construct permanent, but submersible bunds in 1974. In earlier times the embankments used to be repaired just prior to the
cultivation season; this recurring cost was feasible due to the large holdings and cheap availability of labour. With the turn in economics and social changes, this became difficult. Permanent embankments in polders were built mostly by state intervention; through schemes such as the Kuttanad development Scheme. However certain serious environmental consequences such as prevention of soil enrichment by flood water silt deposits, inability to flush out acidity and prevention of fish ingress and growth during the fallow period resulted. This further impoverished the organic status of the soil that used to be replenished by annual floods. The roads constructed as symbols of "development" programmes together with these embankments have further fragmented the wetland eco-system into tiny units and disrupted the natural hydrological balance. Effective draining of the toxicity developed by the fertilizer and pesticide residues became impossible and the system further deteriorated (Kannan, 1979).

The periodic tidal flow, which used to flush the water body, has been completely prevented chiefly due to the obstruction created by the salt barrier at Thanneermukkom. Consequently, the water drained off from the rice fields, containing large amounts of pesticide and fertilizer residue, remains stagnant (Thomas et.al. 1993). Widespread fish mortality was reported in Kuttanad in 1990 and studies suggested that deterioration of the environmental
quality of the system was the prime reason (Nair and Pillai, 1993). Water pollution is one of the main causes of reduction in numbers of the giant fresh water prawn, which migrate from the fresh water to the estuary and back again (Sebastian, 1991). The water body gets polluted quickly, resulting in the spread of diseases like dermatitis, jaundice, colitis and amoebic dysentery (Kannan, 1979; KSSP 1978; KWBS, 1988).

Kerala had a gross rice cultivated area of 7.79 lakh ha. In 1960-61 with a production of 8.84 lakh tonnes and an average yield of 1164 kg per ha. It went up to 8.75 lakh ha. in 1973-74 with a production of 12.57 lakh tonnes and a yield of 1437 kg. per ha. The maximum production so far recorded was 13.76 lakh tonnes during 1972-73 from an area of 8.75 lakh ha. with a yield of 1572 kg per ha. The area came down to 4.31 lakh ha. during 1996-97 with a production of 8.71 lakh tonnes and a yield of 2023 kg. Per ha. During 1998-99 it was only 3.53 lakh ha. with the production of 7.27 lakh tonnes and a yield of 2059 kg/ha and has come down to 3.01 lakh ha in 2002-03.

A number of reasons could be attributed to this steady decline of rice growing area during the last decade. In the post independence period, as domestic production was not sufficient to meet demands, the price of rice remained high. Since the mid nineteen sixties the retail price of rice in Kerala registered a notable
increase. The increase in the retail price of rice was over four fold between 1959 and 1973 and was one of the major reasons for the increase in area (Panicker et al. 1978). The absolute retail price for rice rose until 1975 and then fell until 1980-81. The decline in rice cultivation was due to the fall in price of rice since 1974-75 and the rise in the cost of cultivation mainly due to the increase in the wages of agricultural labour (Panicker 1980). Historically Kerala was a food deficit area and the question of food security was always an important preoccupation of the state. The import of rice, the staple food, started long ago from 1852, to relieve famine conditions. The crisis situation of the 1940s initiated the process to augment food production by extending cultivation to all possible areas. The rising trend of rice in the late 1960s to mid 1970s was ascribed to the various five-year plan measures to enhance food security in the state (Isaac et al. 1992). The increase in the domestic production of rice during the 1950s and the 1960s did not significantly reduce Kerala’s dependence on supplies from outside the state. Since the mid 1970s, the gap between internal consumption and production tended to widen, and was filled by imports through central government allotment and private trade. The import of rice into the state increased threefold between 1974-75 and 1978-79. The alternate governments, which came to power, followed the same welfare policies and ensuring grain
availability through the public distribution system (PDS) at cheap prices was high on the agenda of both. The supply of rice and other food grains in the open market improved so much that there was a perceptible fall in the absorption of food grains through the PDS. The quantity of rice distributed to the rice shops increased through the 1980s to reach 1.8 million tonnes in 1992 (Nair and Pillai 1993). Due to large scale imports the supply of grain increased and local production became less significant. The most recent estimates show that the grain distributed exceeds domestic production by close to a 100% (Balakrishnan 1999). This improvement in the supply position, the price factor and rise in the cost of cultivation jointly brought about the unprecedented decline in area under rice since 1974-75.

The cost of cultivation and profitability is a crucial determinant of land use. The increasing cost of cultivation and hence declining profitability has been put forward as one of the major factors for the shift away from rice (George and Mukherjee, 1986; Unni, 1981; Panicker, 1983; Kannan and Pushpangadan, 1990). Rice cultivation demands timely labour for different operations like ploughing, transplanting, water control, weeding, manuring, harvesting and threshing. All these operations need specific amounts of labour at a particular time, which makes rice cultivation highly labour dependent.
An analysis of cost of production of rice in different states in the Indian Union by Rice Commission (GRC 1999) reveals that in terms of cost of production Kerala ranks first with Rs. 522 per Qtl as compared to 185 in Punjab. While the price of rice tripled during the period from 1970-1971 to 1988-89, labour costs registered a six-fold increase (Sunny, 1991). In most of the states of India agricultural production and real wages were found to have moved in tandem, except in Kerala where wages have increased while agricultural production declined (Jose, 1988). The rate of productivity growth was also found not to be commensurate with that of real wages in rice cultivation (Kannan, 1979). Out of the 15 major rice producing states in the country Kerala ranks 7th in terms of productivity and 14th in terms of area. Jose (1977) argues that managing labour in the case of rice operations became difficult in part because of the critical role played by labour and the stand adopted by trade unions. In certain parts of the state, due to trade union and government interventions, the farmers have lost not only control over wages, but also lost decision making power regarding the size of the work force to be employed and mechanization of operations (Kannan, 1988).

In Kuttanad, the cost of the total inputs has increased more than the value of output. While the input cost increased by around 254% in a decade, the increase in the value of output was
only 95%. This mismatch in increases between input costs and value of output during the decade is reflected in the lowering of net returns from Rs.3569 per ha. in 1988 to a negative net return of Rs 247 per ha. in 1998. The rice equivalence of cost of cultivation was worked out by dividing the total input costs by the unit price of rice in the respective years. Such estimates would show that the rice equivalence of cost of cultivation for the year 1988 was 1983 kg. per ha. which increased to 3239 kg. per ha. in 1998 (Narayanan, 2003).

Labour cost forms the major component of cost. The dominant cost of wages in the face of low productive nature of rice cultivation was the major concern raised by farmers. The disproportionate rise of wages in relation to prices was also noted by a recent regional study of Kuttanad, which compared the trends during the period 1960-1987. In the period between 1960-61 and 1971-72, when money wage rate increased by 243%, the increase in farm income was 328%. In the later period, from 1975-76 to 1986-87, the farm income increased only by about 116% against an increase in wage rate of 215% (Thomas and Thomas, 1999). The rise in farm income in the first period might have been partly due to the productivity increase during the initial phase of green revolution technology which must have declined after the mid 1970s owing to the agro-climatic limitations. However, even when
the returns are not commensurate, the wages could not be lowered due to the active presence of trade unions (Narayanan, 2003).

In addition to increase in cost of production, the non-availability of labour for crucial and timely agricultural operations was a major constraint to raise cultivation. (Francis, 1991) reported that 91% of the farmers experienced shortage of labour for harvesting, 69% reported shortage for weeding and around 25% shortage for transplanting operation in cultivation.

Material costs, which include the expenditure incurred for inputs like seed, organic manure, lime, fertilizers, pesticides, fungicides and weedicides have been reported to be the second major group of cause. Due to the hike in cost of fertilizers, most of the farmers could not afford the doses recommended by the agricultural department. The unit price of pesticides, fungicides and weedicides have increased enormously.

The farmers of Kuttanad have reached a point where it has become practically impossible to continue cultivation of rice. The above-mentioned facts speak for themselves of the state of affairs of rice farming in the rice bowl. The steady decrease in area under cultivation is a cause of alarm not only from the point of view of food security but also due to its bearing on the ecology of the wetland and large scale conversion of the wetlands into garden lands and deprival of livelihood opportunities to the dependent
labour. The wetland system is so crucial to the ecological balance of the region owing to the unique topography of the state that any deterioration of the system would lead to catastrophic consequences. The wetland system has to be maintained at all costs. To put rice cultivation back on the tracks we have to think seriously of finding ways to attract farmers back to the fields. We need to devise systems by which cultivation can again be made profitable and sustainable. In the present state of affairs it is extremely difficult to do so unless rice cultivation is integrated with other crops, which would be mutually helpful and sustainable. Even in the regions where green revolution strategy was adopted, such a crop rotation has been in vogue.

Even in the green revolution areas the emergence of second generation problems have been found to limit production viz. (i) declining or paltering of farm productivity due to depletion of organic matter coupled with depletion of soil fertility due to over mining of native nutrient reserve, (ii) declining fertilizer use efficiency, (iii) ground water depletion due to over exploitation in utter disregard to level of natural rechargeability, (iv) increasing problem of salinity-alkalinity in the commercial areas due to excessive and indiscriminate use of irrigation water and (v) build up of disease-pest pressure by continuous cropping and increased parietal uniformity and excessive dependence of
agrochemicals and increased cost on plant production (Siddique, 1999).

As rice is one of the least water efficient food grain crop besides being the most water intensive, there is a dire need to insulate production technology with cost effectiveness to ensure economic sustainability in rice farming.

Since farming is the biological process of transformation of solar energy into biomass, involving the major resources land and water, approaches that facilitate optimum utilization of their production potentials must be ensured. The options available will be; (i) to devise sustainable rice production practices by blending appropriate integrated enterprises, (ii) to support rice production through subsidies and incentives and make rice production competitively profitable considering the unique ecological role of the wetland. It is in the wetland that intensification adds to profitability and diversification ensures sustainability. Even in the case of green revolution strategies, high yielding technologies in rice have been more successful when coupled with appropriate crop rotations. It has been highlighted that the high yielding technologies in rice were highly productive and profitable in rotation with various crops and cropping sequences. (Siddique, 1999)
Integrated farming systems which depend on natural processes that can convert organic wastes of one farming enterprise into useful bio products of another have been acknowledged worldwide as the most efficient way of increasing self sufficiency of farm holdings by increasing resources utilization, maximizing yields and diversifying products. Although this kind of farming systems has a centuries old tradition in developing countries, the practice which emphasizes environmental quality and the resource base on which agriculture depends has emerged only recently as one of the most prominent issues across the world. Examining different techniques for agricultural sustainability, Ikerd (1989) pointed out that it should involve farming systems that are capable of maintaining their productivity and usefulness to society indefinitely. McRae et al. (1980) emphasized that sustainable agricultural systems are designed to use existing soil, nutrients and water cycles and naturally occurring energy flows for food production that would make a farm more ecologically and economically diverse and self-reliant. They also pointed out that a lot of information gaps exist in our present knowledge about these farming systems, particularly, the cycling of nutrients.

Implementation of rice-fish integrated farming is a recent development in Kerala. Studies conducted by the Kerala Agricultural University at the Regional Agricultural Station,
Kumarakom, have set the pace for a change. These studies indicate that in additional to rice production averaging 3 tonnes/ha, fish yield ranging from 600 to 1000 kg/ha could be obtained by the simultaneous farming of rice and fish. (Padmakumar et al., 1993). As compared to the practice of simultaneous farming which requires several modifications to the rice fields to protect the fish from the inherent risk of pesticide application, rotational farming of rice and fish was shown to be more advantageous as it permitted better management practices for both rice and fish. In these investigations, wherein Indian major carps, common carps and *Etroplus* and the giant fresh water prawn *Macrobrachium Rosenbergii* were polycultured, yield touched 1005 kg/ha without any additional expenditure on feeding or manuring. From these observations, it was inferred that rotational farming of rice and fish was a viable proposition for Kuttanad. Common Carps and Grass Carps were shown to be suitable candidates for culture in this situation. Giant fresh water prawn *M. rosenbergii* was demonstrated to be an economically important species suited to Kuttanad rice fields and they were found to attain 180 to 200 gms in 6-7 months in the rice field environment (Padmakumar et al., 1988). Under the sequential system, rice yield varied from 1.35 to 4.21 tonnes/ha and fish production ranged from 537 to 1005 kg/ha during a period of 154 to 184 days under a low input extensive
farming regime. High percentage of survival of fishes and better management practices led to perceptible improvements of soil conditions where fish was integrated, with an apparent increase in rice production in subsequent years. The cost of production of fish was considerably reduced (Rs 3.5/kg) as the rice crop residues especially straw and stubble provided adequate detrital supplements to fishes (Padmakumar et al., 2002). The weed control facilitated by fish integration in rice fields was prodigious and perceptible as also reported earlier by several others (Satari and Trimorini, 1974; Nie et al., 1992).

Although the ecological and economic superiority of this innovative farming system was demonstrated, the question of diffusion of the technology to the farmer remained infracted till 1993 and became fruitful, with the initiation of an on farm participatory trial.

In the participatory on farm field trial undertaken in a polder of 8 hectares owned by a farmer in Pazhayakayal in Kumarakom, the rice fish rotation yielded fish production as high as 2500 kg/ha than the yield of 1005 kg/ha obtained in the smaller on station trial plots (0.18 ha). This observation indicated that fish could obtain much higher growth when left to grow in larger impoundments even under an extensive farming regime. The effect of fish culture on the succeeding rice crop was also
perceptible. The success of these on farm trials can only be attributed to the continuous farmer scientist interaction and partnership facilitated by the participatory research. The complimentarity of rice-fish integration in such large polders was also striking. In the studies that followed when livestock and poultry were integrated to the rice-fish system, the use of animal manure not only increased fish yields but also led to the improvement of the organic status of the rice fields. This was reflected in the increased rice yield as pointed out by Padmakumar et al. (2002).

The multi-level farming integration necessitated the farmer's personal involvement in farming enterprises more intimately, and with the participation of the researchers, this led to the evolving of an on-farm multi-level integrated mode of rice-fish, livestock and poultry along with farming of inter-crops of pineapple and banana on the polder dykes. In effect, integrated fish culture became the starting point that promoted in situ diversification of farming enterprises. This helped to save cost of paddy cultivation by Rs.2134/ha on land preparation, fertilizers, plant protection and weeding costs. The economic advantage of the integration was appreciable and revealing. The net income increased to Rs 24057/ha in 1998 as compared to a negative return of Rs 247/ha
for a single crop of rice prior to these interventions (Narayanan 1998).

It can only be legitimately inferred that the salvage of agriculture in Kuttanad needs drastic transformations that would make farming economically, socially and ecologically viable. For a people that hold on tenaciously to old agricultural practices oblivious of the big changes that are happening around, the adoption of a farming system that would integrate traditional farming practices with new ones would be an opening worth considering. So long as agriculture remains the backbone of our society, any attempt that would make it more viable and profitable would be strongly encouraged. Rice-fish rotational farming is suggested as one of the options for an agricultural order in the low lands in Kerala on the verge of rapid decline.

Various authors have highlighted the need for intensified research in the field of rice-fish integration. Dewan (1992) stressed the need for further works to seek the best species composition, optimum stocking rates, low cost supplementary feed for fish and also the analysis of cost-benefit of this system. Li (1992) highlighted the need for studies, which would help to establish various models of rice fish systems to suit different agro-climate and socio-economic conditions.
Ghosh (1992) emphasized that very little research has been done to find out the ideal fish species and its stocking densities under varying ecological conditions. Koesoemadinata and Costa Pierce (1992) indicated the need to formulate ecological guidelines for fish cultivation in rice fields. Most of these works have pointed out the lack of organized studies regarding the carrying capacities of fish in rice fields, and how agronomic practices of fertilization, feeding, different cropping systems and soil types affect the aquatic food web.

Ali (1992) reported that the major constraint on the expansion of rice fish farming in Malaysia is the lack of research and development on improving the culture and management techniques and also the immediate demonstration of the new culture methods and management techniques to the farmers. Sevelleja (1992) stressed the need for more research on the socio-economics of rice-fish farming systems. He has emphasized for focused research on impact assessments, optimum resource allocation, substitution and complementarity among commodities, full employment and labour resources and social desirability of the technology. Lightfoot et. al. (1992) highlighted the dire need to quantify the effect of fish on rice yields and suggested that future researches ought to be directed towards ensuring not only
favourable but also predictable outcomes with regards to integrated mode of cultivation.

Halwart (2003) elucidated the need for an integrated approach to the studies on rice-fish farming, and called for cooperation and exchange of ideas between the different disciplines.

The present study aims to elucidate the advantages of a resource based approach to farming in the wetlands of Kuttanad in the context of the near 'crisis' situation in wetland rice farming. The study also intents to establish the dire need for a paradigm shift in farming so that water is identified as the greatest strength of the region and agro-aqua integration offers an opportunity that can ensure sustainability in production.