Overview of farming practices in the water-logged areas of Kerala, India

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Abstract: Water logging is one of the major problems of land degradation in India. Unscientific management of soil, water and crops in irrigated lands, and obstruction of natural drainage systems by various developmental activities are the main factors responsible for disrupting the balance of inflow and outflow of water, leading to water stagnation. While irrigation has increased by leaps and bounds, its attendant problem of water logging is now plaguing substantial area of agricultural lands. The low-lying areas of Kerala, the southernmost state of India, are potential areas of paddy production. But these areas are situated below the mean sea level and have serious problems of water-logging. About twenty five percent of total paddy lands in Kerala are water-logged; especially in Kuttanad, Pokkali, Kole and Kaipad areas. An integrated rice-shrimp/ prawn farming are practiced in these areas. One rice crop followed by shrimp/prawn capture provides a substantial subsidiary income to the farmer. The major issues faced in these areas are mainly related to pollution, eutrophication, encroachment, reclamation, mining and biodiversity loss. As a result of denuding, polluting, draining, filling, etc., these water-logged areas have been under severe threat. The potentiality of these areas should be exploited and necessary measures in conserving these areas need to be undertaken. Sustainable farming where a judicious mix of integrated enterprise concept of resource based planning based on public participation is slowly developing in these areas. A clear perspective and a management system that ensures participation and regulation in resource use are essential.

Keywords: wetlands, ecosystems, India, water-logging, rice-shrimp farming, Kuttanad-Pokkali-Kole-Kaipad
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1 Introduction

A water-logged farm land in the commands of major/ medium irrigation projects is a common sight and is considered as a global problem. In India, six million hectares are waterlogged while the irrigation potential created is only 56 million ha as in the year 2009. With the objective of extensive and speedy development of irrigation in India and to project an attractive cost-benefit ratio of the projects, provision of drainage is rarely made during planning and execution of the irrigation projects. Irrigation induced water-logging is mainly caused by application of excess irrigation water than the crop needs. Command areas of most of the irrigation schemes throughout the country affect the problems of water logging[1].

The low-lying areas of Kerala, the southernmost state of India, are potential areas of paddy production. But these areas are situated below the mean sea level and have serious problems of water-logging. The details of the water logged areas in Kerala are given in Table 1.

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Table 1 Details of the water-logged areas in Kerala, India

Details	Water-logged areas			
	Kuttanad	Pokkali	Kole	Kaipad
Districts	Alappuzha, Kottayam & Pathanamthitta	Alappuzha, Ernakulam & Thrissur	Thrissur & Malappuram	Kozhikode & Kannur
Area (ha)	40,000	8,500	13,000	2,500
Cultivation period	First crop-Punja Oct-March	Jun-Oct	Nov-Aug	Jun-Nov
Special features	• Delta region of 5 rivers. • Connected to Arabian Sea. • Similar to Kole land. • Acidity, salinity & flood.	• Rice-shrimp farming system • Pokkali rice got GI registration	• Central 'rice bowl' of Kerala • Reserve of Birds	• Brackish water areas • Rotational farming of rice and shrimp

The distribution of the water-logged areas in Kerala is shown in Figure 1.

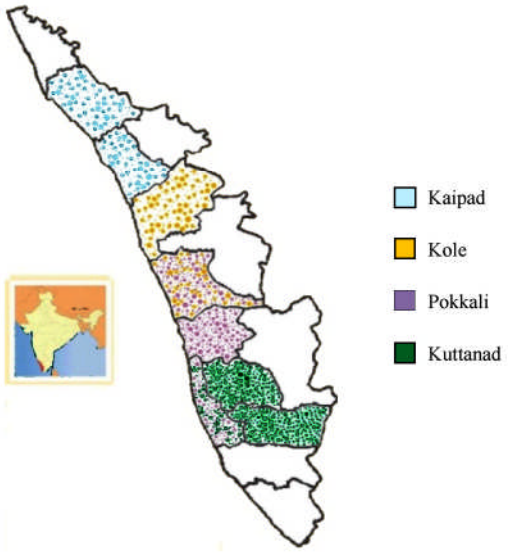

Figure 1 Water-logged areas of Kerala

1.1 Current scenario of water-logged areas of Kerala

The land reclamation in Kerala has a long history, though its exact period of origin has yet to be traced out. But *Kayal* reclamation, the main part of land reclamation work and of recent origin was started in 1833. The pioneering attempt of large scale *Kayal* reclamation was started in Kuttanad region. Lured by the successful reclamation work and profitable paddy cultivation in Kuttanad areas, some enterprising farmers slowly turned their attention to similar water-logged areas especially Pokkali, Kole and Kaipad areas. The reduction in agriculture has automatically affected the economic condition of the people of these areas, especially, the farmers and farm workers.

1.1.1 Paddy cultivation in Kerala

Paddy cultivation is prevalent in the low land areas such as Kuttanad, Pokkali, Kole and Kaipad areas. In all the water logged areas in Kerala, the crop is raised as rainfed crop, though irrigation facilities are now being provided on an increasing scale. The cultivation of paddy in the backwater presents special features. No crop can be grown in these parts during the monsoon season when inland water floods the lakes. Cultivation is also not possible after April when the sea water enters these areas. To control the flow of water, strong bunds are constructed and a number of water channels are provided to drain the overflow. At the end of monsoons, water inside the large lakes is pumped out with the help of water wheels or power driven pumps which are kept working day and night. Afterwards, field bunds are formed, the land is prepared for cultivation, and paddy seedlings are transplanted. Occasionally, during the pre-monsoon showers, the area gets flooded where the excess water is removed using water wheels.

The Kuttanad area remains submerged for greater part of the year and is dewatered after the monsoon is over. There are special large sluice gates which can be operated to let the flood water flow into the sea and to prevent the sea water flooding the lake. Popular in the coastal belt of the State, nearly two-third of the Pokkali cultivation is in Ernakulam district. It is estimated that nearly 20,000 ha of saline soils are under paddy cultivation in Ernakulam, 2,000 ha in Alappuzha and 2,000 ha in Kannur. All the other coastal districts put together have about 1,400 ha of land under cultivation. In order to survive in the water logged field, the rice plants grow up to two meters. But as they mature, they bend over and collapse with only the panicles standing upright. While harvesting, only the panicles are cut, and the rest of the stalk are left to decay in the water, which in time become feed for the prawns[2]. The reclamation schemes were

mostly intended to bring more lands under the rice crop and improve the yield of the existing fields by putting up barriers against the entry of brackish water from the lakes and seas and channeling the flow of fresh water from the river system to these fields[3].

Since mid 1970's, area under paddy cultivation has been declining at a rate of 4.3% per annum. At present, area under rice in Kerala is 2.8 lakh ha and production is only 6.8 lakh tonnes (1 lakh = 100,000). Productivity of rice has been increasing at a very low average rate of 1.3% per annum. The area and productivity of rice in Kerala are shown in Figure 2. The decline in productivity and profitability is discouraging many farmers from pursuing rice farming[4]. Rice cultivation in the State has been steadily shrinking in spite of the best efforts by the Government and various other agencies to boost it.

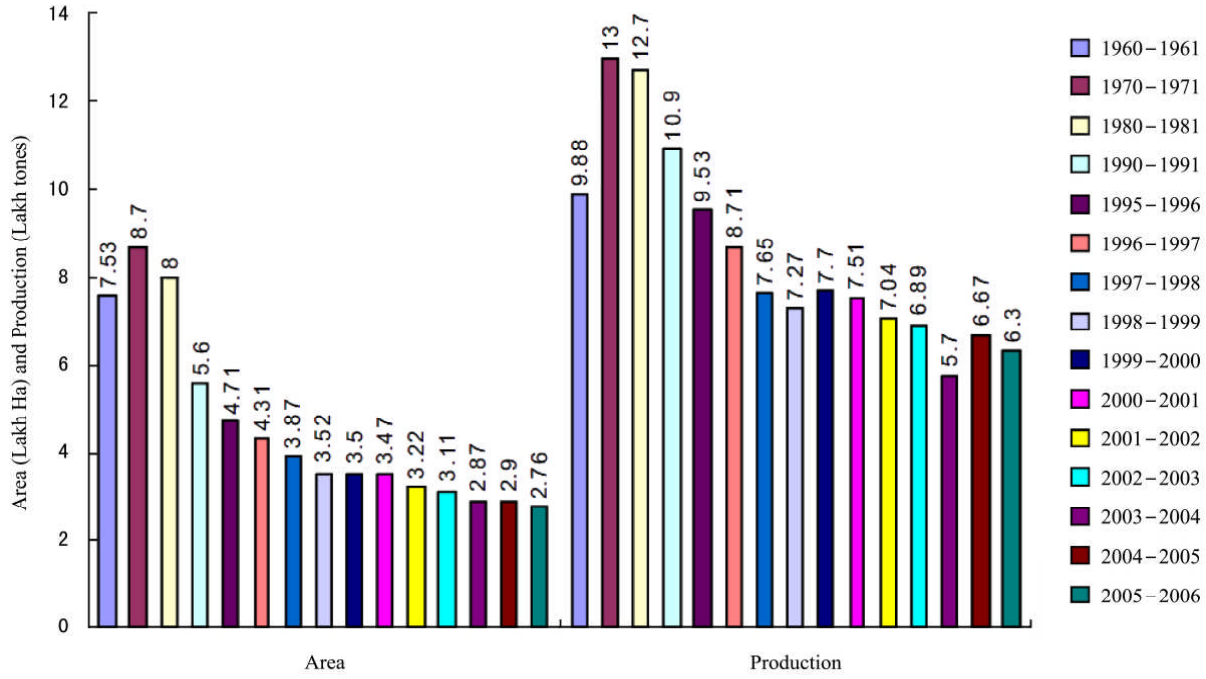

Figure 2 Area and production details of paddy cultivation in Kerala (1 lakh = 100,000)

1.1.2 Rice-shrimp farming in Kerala

The rice-shrimp rotational cropping has supplemented animal protein in the diets of the poor, local population, and is proved to be the most economic utilization of land and family labor, and also provides other benefits such as reducing insect pest pressure and increasing the organic content of the soil[5]. Integrated rice-shrimp farming has turned out to be a viable alternative to effectively utilize the large amount of fertile water available. As paddy fields are complex ecosystems where primary producers and consumers at different levels compete with rice for material and energy, they decrease the overall productivity. However, shrimp culture in paddy fields can turn and recycle the available material and energy into their production, accelerate the productivity of paddy fields and enhance the production potential of traditional farming practice with increased net income[6].

An overview of the current practices being followed in these water-logged areas of Kuttanad, Pokkali, Kole and Kaipad is briefly discussed.

2 Kuttanad

2.1 Description of the site

Kuttanad, the 'Holland of Kerala', is a low-lying area with backwaters, canals and stream networks extending over 874 km^2. There are garden lands at an average elevation of 1 m above mean sea level covering an area of 304 km^2. Kuttanad, the deltaic formation of four major river systems, Pampa, Achencoil, Manimala and Meenachil, confluencing into the Vembanad Lake, lies 0.6 to 2.2 m below mean sea level. The region extends from 9°17' to 9°40' N latitude and 76°19' to 76°33' E

longitude. Rice is the important agricultural product, giving Kuttanad the moniker of "The Rice Bowl of Kerala". The garden lands, or the reclaimed *purayidams* or homesteads with coconut groves, fringed by canals and channels make this a land of richness and beauty[7].

The lake Vembanad extends from Alappuzha in the south to the harbor Cochin in the north where it opens out to the Arabian Sea. Kuttanad is the land made by Kuttans who formed the land by digging the soil by hand often from below the surface of water and carrying it by head load or by country boat. It is a fertile tract of land replenished by the silt brought by the river systems. The area was found to be highly suited to rice cultivation from early days[8]. The topographical and agronomic features of Kuttanad are unique. Since the area is water-logged, cultivation is carried out by enclosing small areas within dykes or bunds and pumping out the water. The cultivated land is broadly classified into three regions:

- The upper Kuttanad consisting of fields relatively at higher levels, but still below mean sea level.
- Kayal lands of backwater.
- The lower Kuttanad with lands lying between Upper Kuttanad and Kayal lands.

The problems of the Kuttanad lands are due to the floods and intrusion of salt water. The flood water from the four rivers viz., Achencoil, Pampa, Manimala and Meenachil spreads out over an area 16 km wide and 80 km long before joining the sea at Cochin. The other major problem is that of saline water intrusion caused by large quantities of sea water entering through the Cochin gut which travels south, to the southern extremity of Vembanad Lake and mixes with the fresh water in the area. The solution to the problems of Kuttanad area will be quick drainage of flood waters, control of flood and prevention of salinity ingress from the Cochin gut. Kuttanad Development Scheme was sanctioned by the State Government consisting of three parts:

- A spill way at Thottapally as shown in Figure 3a.
- A combined road and canal connecting Alleppey and Changanassery.
- Construction of salt water barrier at Thanneermukham as shown in Figure 3b[9].

a. Thottappally spillway

b. Thaneermukkam barrage

Figure 3 Two parts of Kuttanad Development Scheme

The Thottappally spillway diverted flood water from rivers directly to the sea. The Thanneermukkom barrier prevents the ingress of salinity into the polders during summer season and also retains the fresh water inflow from the rivers into the lake. Only two-thirds of the original number of gates are opened in July to release flood flow, but the gates are closed during mid-November. The structure keeps the water free of salinity, which allows another crop in dry season. Before the construction of the Thanneermukkom regulator, the entire backwater area used to become saline or brackish during the pre-monsoon period. Though the construction of the spillway has not made any perceptible improvement in the control of floods, it helped in raising additional paddy cultivation in 20,000 ha. Thannermukkam barrier has been successful in preventing the salinity intrusion during summer, but the incomplete construction of the barrage with an almost one-third earthed up middle portion further slowed the flood water recedence during the monsoons and brought about catastrophical changes in the ecosystem of Kuttanad. The introduction of reinforced granite bunds instead of earthen bunds to facilitate additional paddy crop during monsoons have also done extensive damage to the environment in the

upper reaches of Kuttanad[10].

2.2 Cultivation practices

2.2.1 Rice cultivation in Kuttanad

Rice is cultivated in an area of 55,000 ha, identified as *punja* lands of Kuttanad, constituting several *padasekharams* or contiguous fields known as polders, separated by channels and bunds. The ring bunds are renovated and dewatering is done with the cessation of the North-East monsoon during November-December months. After dewatering, three rounds of ploughing are done incorporating cattle manure and ash. Fields are then leveled and sprouted seeds of short duration varieties are broadcasted in January. The crop is harvested in May, soon after which the field gets flooded. Rice cultivation in Kuttanad areas is divided into blocks of 20–80 ha each with embankments all around built with mud taken from the bottom of the lake. Immediately after the monsoons, the water is pumped out of the blocks with the help of the electric pumps till only a few inches of water are left. The soil is then puddled and leveled and sown with germinated paddy seeds.

The agricultural practices and cropping methods used in Kuttanad are quite unique when compared to those in the rest of India. Since much of the land lies below the sea level, the paddy fields situated along the waterways need to be protected by strong and carefully designed ring bunds as shown in Figure 4. The maintenance of these ring bunds in itself is a huge labor intensive operation that needs the deployment of thousands of farm workers every year. Water is let in and drained out from time to time as per changing requirements of the paddy crop. In olden days, huge waterwheels as shown in Figure 4 were annually driven for the purpose of both letting in and dewatering the paddy fields. In recent time, the waterwheels are increasingly being replaced by electric motor pump sets. Recently, Kuttanad package, a mega project of the Govt. of India for $ 4.03 billion is being implemented for the rejuvenation of Kuttanad as suggested by Dr. M. S. Swaminathan Commission.

a. Water wheels used in Kuttanad

b. A typical rice field of Kuttanad with surrounding ring bunds, leaving the water courses for navigation, drainage and irrigation

Figure 4 Unique agricultural practices and cropping methods used in Kuttanad

2.2.2 Rice-shrimp farming in Kuttanad

In Kuttanad, double cropping of rice may not always be feasible due to floods during the monsoon and this combined with low returns from rice cultivation due to the high cost of land lease and labor has tempted the farmers to abandon one crop of rice and instead culture fish and/ or prawn during the season, leading to increased benefits. The ideal season for rearing fish and prawns in the rice fields of Kuttanad appears to be March to October. This arrangement also reduces the production cost of rice since the soil is soft and clean, after the fish/ prawn harvest and allows immediate seeding and transplanting. Prawn filtration in the adjoining rice fields of backwaters is a unique feature of the inland-fisheries of Kerala[11].

2.3 Challenges

• **Emerging tourism:** The entire Vembanad Lake with its small islands adjoining lagoons, backwaters and reclaimed rice fields has immense tourist potential. The reclaimed wetlands are under the threat of further reclamation not only for high valued crops and construction, but also for real estate. The measures

taken up by the Government for promoting tourism in Kerala, and popularization of the concept of ecotourism have added new dimension to land use in Kuttanad. But, considering the fragile nature of these wetlands, unbridled promotion of tourism will not only pollute the environment but also the ethnic culture.

• **Vanishing Mangroves:** Fringed on the eastern banks of the Vembanad Lake, the evergreen stretches of mangroves, the last relic of this tropical vegetation which harbored a variety of endemic and exotic species of birds which make the region a hot spot for naturalists and ornithologists are on the verge of extinction.

• **Drying wetlands:** The traditional wetlands are slowly transformed into garden lands on one side and are utilized for intensive fish farming or for making palaces in lakes on the other. The influence of foreign money and the westernized lifestyle have kindled a natural instinct in the minds of common people to achieve material welfare irrespective of their social or educational status to become rich within the shortest possible time.

• **Capture fisheries:** The Thaneemukkam regulator has divided the backwater into a saline or brackish region downstream on northern side, and a fresh water region south of it. This tract was earlier rich in estuarine fish fauna, consisting of species originating from the sea, fresh water species and true estuarine species. Due to the construction of the regulator, some of these species have now vanished from the area, while others have become a rarity.

• **Impact of developmental activities:** The construction of Thanneermukkom regulator has not only contributed to the flood situation, but also to environmental degradation to a large extent. The construction of Thottapally spillway and permanent lining for earthen bunds has aggravated the flood situation in Kuttanad due to shortfalls in their design. The environmentalists opine that the developmental activities for the past five decades of which the major one is the closure of the regulator, have resulted in severe deterioration and transformation of this wetland ecosystem. The continuous cultivation in rice fields with soil exhausting high yielding rice varieties along with indiscriminate use of fertilizers and pesticides is causing serious degradation of soil in Kuttanad, through the depletion of soil organic matter, increase in soil acidity, depletion of nutrients, accumulation of heavy metals, etc. The persistence of fresh water conditions on the southern side of the regulator has triggered several ecological backlashes such as proliferation of weeds, deterioration of water quality, increased morbidity among the local population and destruction of subsistence fishery on which the local fishermen depended. This deterioration was further fuelled by the ecosystem alterations in the name of conversion for intensive agriculture.

3 Pokkali fields

3.1 Description of the site

Pokkali is a unique variety of rice that is cultivated in an organic way in the water-logged coastal regions of Ernakulam, Alappuzha and Thrissur districts of Kerala extending a total area of 6,274 ha. The region extends from 9°00'–10°40'N Latitude and 76°00'–77°30'E Longitude. The lands for Pokkali cultivation are low lying marshes and swamps situated near the estuaries of streams and rivers not far from the sea. They are water-logged with a poor drainage system and are subject to tidal action throughout the year as shown in Figure 5.

a

b

Figure 5 Pastoral view of Pokkali fields

The sector wise distribution of Pokkali fields is shown in Figure 6.

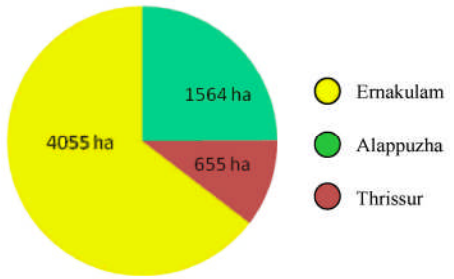

Figure 6 Sector wise distribution of Pokkali areas

The district wise distribution of Pokkali fields is shown in Figure 7.

District	ADA/Block	Sl.No.	Krishibhavan	Padam	Area (Ha)
THRISSUR 655 Ha	I Kodungallur 258 Ha	1	Kodungallur	2	256
	II Vellanikkallur 282 Ha	1	Vellanikkallur	2	100
		2	Puthenchira	2	92
	III Mala 117 Ha	1	Mala	1	40
		2	Poyya	1	77
ERNAKULAM 4050 Ha	IV Nedumbassery 25 Ha	1	Puthenvelikkara	1	25
	V N.Paravur 695 Ha	1	Ezhikkara	5	357
		2	Kochuvelly	6	287
		3	Chittattukara	1	21
	VI Aluva 246 Ha	1	Varapuzha	31	248
	VII Kaamassery 597 Ha	1	Cheranelloor	2	122
		2	Kadamakkudy	14	475
	VIII Tripunithura 319 Ha	1	Tripunithura	1	200
		2	Kumaloor	3	58
		3	Maradu	2	60
	IX Mulamthuruthy 100 Ha	1	Udayamperoor	1	100
	X Vyttila 1158 Ha	1	Chellanam	11	704
		2	Kumbalanghi	8	434
		3	Vyttila	2	20
	XI Njarakkal 916 Ha	1	Pallipuram	2	37
		2	Kochuppally	4	269
		3	Edavanakkad	4	170
		4	Nayarambalam	2	140
		5	Narakkal	8	124
		6	Elamkunnapuzha	7	106
		7	Mulavukad	10	88
ALAPPUZHA 997 Ha	XII Paravoly 215 Ha	1	Arookkutty	1	20
		2	Perukuzhi	2	49
		3	Paravally	6	79
		4	Thekkekadassery	4	52
		5	Chennampallipuram	2	15
	XIII Kuthiyathodu 782 Ha	1	Kodamthuruth	9	224
		2	Ezhupunna	12	380
		3	Aroor	9	178
Total 3	XIII	34		178	5707

Figure 7 Pokkali areas at a glance

The soil is stiff impervious clay, but rich in organic matter. It is bluish black in color and is hard and creates deep fissures when dry and sticky when wet. Pokkali fields are low lying and immersed in water. These fields are naturally connected to the Arabian Sea through backwaters and canals. The Pokkali field is a unique eco-system prevailing in the coastal saline tract of central Kerala with rich bio-diversity and amazing capacity to generate organic paddy and shrimp alternatively[12]. The harvesting of Pokkali rice is as shown in Figure 8.

Figure 8 Harvesting of Pokkali rice

3.2 Cultivation practices in Pokkali

3.2.1 Rice Cultivation in Pokkali

The rice is cultivated from June to early November when the salinity level of the water in the fields is low. From mid-November to mid-April, when the salinity is high, prawn farming takes over. In order to survive in the water-logged field, the rice plants grow up to two meters. But, as they mature, they bend over and collapse with only the panicles standing upright. Harvesting takes place by the end of October. Only the panicles are cut, and the rest of the stalks are left to decay in the water, which in time become feed for the prawns that start arriving in November-December and is followed by prawn filtration as the second phase of the Pokkali farming. The total Pokkali lands were originally estimated to be 25,000 ha. Large areas are converted for coconut cultivation and other purposes. Year by year the area under Pokkali cultivation is declining. In another 2,000 ha, paddy cultivation is done occasionally i.e., only when the climatic conditions are favorable. About forty to fifty percent of the potential yield is lost because of lodging and associated damages caused by fish, tortoise and rats. Quite apart from such losses and the difficulties experienced in paddy harvesting, field clearing for the succeeding selective stocking of prawn is also problematic under such situations[13]. In Pokkali system, one rice crop followed by fish or prawn capture provides a substantial subsidiary income to the farmer. Pokkali fields are highly fertile and the pest and disease incidence is below threshold level, and hence, manuring

or plant protection operations are not necessary for Pokkali farming systems, making Pokkali rice natural organic rice. Pokkali rice got GI registration in the year 2008–2009.

In 1996, the Government instituted the Pokkali Land Development Agency [PLDA] for the promotion of paddy cultivation in the wetlands. The information obtained through this agency helped to undertake a highly disaggregated analysis of the activities of Pokkali *padashekarams*. According to the PLDA, the total area under Pokkali has shrunk from 25,000 ha a few decades back, to a mere 8,500 ha[14]. Only 5,500 ha of that are actually under rice cultivation. The rest is either left fallow or used only for prawn farming. Unavailability of farm labors, especially for harvesting, is the main cause for the decline. As per the latest information of the media, the Pokkali cultivation exists only in 967 ha.

3.2.2 Rice-Fish/ Prawn culture in Pokkali

The Pokkali fields are effectively used for fish/ prawn farming after the harvest of the Pokkali crop. The seasonal rice and fish farming is effectively done over centuries. In this natural system, the ecological balance is maintained and a reasonable profit is obtained by the farmer. When the monsoon subsides, the backwaters and canals become saline and juvenile prawns and fingerlings of other fishes come in large quantities in the outer canals. They are guided to the fields through trap sluices and the sluice gates prevent them from going out. Thus, they are allowed to grow in the field. The waste materials of Pokkali rice cultivation forms the natural food material and will meet all the food requirements of the fish crop. In this system, no selective stocking or supplementary feeding are done[15]. The monoculture shrimp farm is shown in Figure 9.

Figure 9 Monoculture shrimp farm

The types of culture practices followed in the Pokkali fields are prawn filtration, extensive prawn culture, and the modified semi-intensive culture. Prawn filtration, is organized by collecting seedlings entering the estuary during high tides in the Pokkali fields, which ensures high rates of utilization of coastal wetlands in the area. The crop is harvested within 150 days. Prawns in Pokkali fields subsist on organic matter from decayed stubble, drying waterweeds, etc., and in turn the fields are enriched in manure and the excreta of organic wastes from fish and prawns. *Chemmen vattu*, or the Extensive prawn culture activities are done round the year and is not confined to six months alone. Culture during the next six months is on a commercial basis and the laborers have the right to catch fish only at the end of the season. Semi-intensive culture form is the modern culture system, which applies modern science and technology to produce living organisms. It is not practiced in its true form rather it is a modified semi-intensive culture system that is being practiced in the backwaters of Cochin[16].

3.3 Challenges

• **Labor intensive:** Pokkali harvesting is highly labor-intensive, and the young generation of the traditional farm workers' families prefer other trades, notably construction work in booming Cochin.

• **Shift to monoculture of prawn:** The unsustainable monoculture of prawn is catching up in the Pokkali lands and has gained momentum in the last decade. Though this provides higher net returns over the traditional rice-prawn culture in the short run, it is found to be unsustainable in the long run, both in the ecological and the social context. Despite the State Governments' direct intervention making the monoculture of prawn illegal, more area is being gradually brought under fallow-prawn and prawn-prawn systems, owing largely to the multitude of constraints associated with the labor intensive rice cultivation in Pokkali lands. This poses a challenge to the *in situ* conservation of salinity resistant indigenous rice varieties and cultivation practices[17]. Due to changing economic realities, farmers are showing a tendency to convert these seasonal lands to single crop-prawn-system.

• **Anthropogenic threats:** Pokkali fields are under

serious anthropogenic threats as they are being converted for other purposes like roads, bridges, residential or commercial activities. Invasion of weed, and over exploitation of fish and prawn are some of the major reasons for the decline of the lands. Also, these areas appear to be one of the most preferred landfills for dumping solid waste and an ultimate point for discharging untreated industrial and domestic effluents.

4 Kole lands

4.1 Description of the site

Kole wet lands is one of the largest and the most important wetland of Kerala. The name 'Kole' refers to the peculiar type of cultivation practices carried out from December to May and is a *Malayalam* word which indicates 'bumper yield' or high returns incase floods did not damage the crop. The rice cultivation in Kole had been started early as 18th century by reclaiming the Thrissur 'Kayal lands' by erecting temporary earthen bunds. It spreads over Thrissur and Malappuram district, extending from the northern bank of Chalakkudy river in the south to the southern bank of Bharathapuzha river in the north. The area lies between 10°20' and 10°40'N latitudes and 75°58' and 76°11'E longitudes. Karuvannur and Keecheri rivers drain the Kole lands and finally discharge into the Arabian Sea[18]. The Kole land is a flat saucer shaped low-lying area, flanked by lateritic hills on the eastern and western margins as shown in Figure 10. Water level rises up to 5.5 m during the South West monsoon. The cyclical nutrient recharging of the wetland during the flood season rendered the area as one of the most fertile soils of Kerala. This is indicated by the fact that while the average productivity of rice in the State is less than two tonnes per hectare, Kole lands yielded four to five tonnes of rice per hectare[19].

The combined drainage area of the Keechri and Karuvanuur Rivers is 1,685 km^2 with the monsoon flow of 2,265 mm^3 and total flow of 2,388 mm^3. The Karuvanuur river has two tributaries namely Manali and Kurumali. Peechi river and its tributaries feed the Manali River. Formerly, there were high flood in this area during the monsoon period. However, with the completion of Chimmini and Mupply irrigation projects, it is claimed that more efficient floodwater control became possible and continuous flow is usually maintained during the summer. The 'North Kole' stretches from Keecheri river in the north to Karuvanuur river in the south. The area extending from south bank of Karuvannur river to Vellangalur region in the south is called as 'South Kole'.

Figure 10 Kole lands

A network of main and cross canals connects the different regions of the Kole to the rivers and it facilitates good drainage. Thuppan thodu and Nedum thodu are the two major drainage canals of the south Kole. The Panoli canal flows through the north and northwest of Irinjalakuda and drains into the Chemmanda Kayal. Drainage water from Karalam Kole lands flows into Karuvannur river through Nandi sluice and through Muriyad – Moorkanad canal. From the Muriyad area Thamaravalayam canal drains into the Karuvannur river during monsoon and convey irrigation water from the river to the Kole lands during summer crop periods.

The main exit for the water collected in the south Kole is the Enamakkal regulator and that of the North Kole the Idiyanchira regulator. These regulators also control the salt-water intrusion into the paddy fields. Every year a number of temporary earthen bunds known as *chiras* used to be put up in the river at various locations soon after the north-east monsoon for temporary storage to irrigate the lands on either side of the rivers and raise the water table. The construction of these bunds often involves local labour and skills of the local communities. The earthen bunds were in most places constructed using bamboo, areca poles and clay[20].

Hameed[21] investigated the chemical characteristics of Kole land soil and reported that the organic matter content of the soil is very high. In the surface level, it varies from 2.07% to 4.16%. A lesser amount of organic matter is seen in the subsurface layer of 1.37%–9.7%. Based on the textural analysis, Kole land soil has been classified into clay, sandy loam, sandy clay loam, and clay loam[22].

The Kole land area is a submerged plain land representing piedmont type of deposits, silted up with alluvium brought down by Karuvannur and Keechery river. Texturally, the material ranges from fine to coarse clastic particles derived from lateritic hills surrounding the area. Black carbonaceous clay with a lot of large decomposed tree trunks is often seen in the Kole indicating that fluvio-estuarine deposition process have played a major role in the formation of Kole lands. The presence of deep sand layers seen in several areas provides evidence that the area might have been under the sea in the recent geological past[23].

Moderate climatic conditions are experienced in the area with temperature range of 21–38℃. The Kole lands receive two well-defined rainy seasons, the South-West and the North-West monsoons. The phenomenon of depression rains noted during October to November is also another source of water for the Kole lands.

4.2 Cultivation practices in Kole

The inundated paddy fields have areas extending from 20–400 ha and have outer flood protection bunds lined one or two sides with coconut gardens and a central water feed canal that regulates intake water supply by gravity through sluice gates. Water drainage is done by pumping with the help of axial flow pump sets of 25–100 hp (1 hp = 745.7 W) capacity that are installed at the side of the bund. The peripheral bunds are tall and strong enough to withstand floods, although occasional flash floods may cause the embankments to overflow leading to crop loss[24].

In order to enable rice cultivation during the early dry season, the *punja*, bunding of shallow parts of lagoon, started at least a century ago. The *padashekharams* or polders as shown in Figure 11, created in this manner cover an area of 55,000 ha. This has led to a number of criss-cross canals which provided a transportation facility all along this wetland. Two of the most important functions of this wetland are agriculture and fisheries. About forty percent of the population in this area is directly involved in agriculture. The main rice crop is *punja* grown in the early part of the dry season. By the completion of the irrigation projects envisaged in the drainage basins and also by the introduction of more diversion schemes upstream, the low-flows to the wetland may dwindle and adversely affect the *punja* crop. However, the major constraint to agriculture in the Kole lands is flooding.

Figure 11 Panoramic view of *Padashekharams* of Kole lands

In each *Padasekharam*, dewatering, preparing of bunds and decision making are done on a collective basis, under the supervision of a *Padasekharam* committee, formed by the farmers. However, the actual cultivation is carried out by the farmers individually. Irrigation of the fields is affected naturally by the rains. Being the low lying areas, irrigation is not a problem. The group farming method of cultivation followed in Kole lands facilitates the use of agricultural machinery on a profitable basis for tillage, transplanting, harvesting, and threshing. However, the fields are almost always prone to water-logging. Hence, dewatering into adjacent water canals is done, using the traditional “Petti & Para” pumps. A single *Padasekharam* has one to six such pumps[25].

4.3 Challenges in Kole

Though it proved to be an internationally important wet land, Kole wetland is one of the most threatened wetlands in the State. Reclamation of land and change in land use pattern are the most serious problems. The

paddy fields are being converted to Coconut, Arecanut and Banana and other cash crops at an alarming rate. The marshes are being 'developed' and new constructions are cropping up. At many places, the wetland has been converted to brick-kilns. Large scale poaching and trapping of birds and fishing are also going on.

The reclamation of Kole lands is proposed by a scheme envisaging the following works.

• Construction of permanent non-submersible bunds in place of the existing temporary submersible bunds, and grouping of smaller units of fields into larger groups.

• Improving the drainage courses and the construction of new drainage channels to ensure effective drainage by channeling the flood flow.

• Construction of an artificial cut at Kuttamangalam to facilitate drainage into the sea and to regulate flood waters.

5 Kaipad

5.1 Description of the site

Kaipad is a saline-prone natural organic rice production tract of North Kerala, like the Pokkali tract of South Kerala. The Kaipad system of rice cultivation is an integrated organic farming system in which rice cultivation and aquaculture are practiced together in coastal brackish-water marshes, which are rich in organic matter[26]. The soil type is saline hydromorphic[27]. The network of backwaters and estuaries serves as an inlet of sea water and causes salinity in the area.

Kaipad lands lie adjacent to Pazhayangadi river and have a spread of about 400 ha, stretching from Kuppam-Pazhayangadi town, to the north of Pazhayangadi-Kuppam river and south of Pazhayangadi-Taliparamba Road. The wetland ecosystem where Kaipad farming evolved consists of marshes, swamps, ponds and paddy fields, which constitute an important landmass for controlling floods, sedimentation, and pollution. The area is swampy and water-logged, experiencing floods during the monsoons and salinity during summer owing to nearness to the river that merges into the sea. The tidal currents from the nearby sea move through the river and enter the Kaipad fields during high tide and flow out from them during low tide. The river water is usually saline except during monsoons. Salt water from the sea enters the river during summer, when flow is low. When the water level rises, the river water flows into paddy fields. The tidal waves entering the fields through the river keep the soil moist even during the summer months. As these lands are immersed in river water, they get rich deposits of highly fertile organic matter; therefore, paddy cultivation requires no artificial manuring and fish species receive adequate food. The Kaipad fields at various stages are depicted in Figure 12.

a. Nursery preparation

b. Vegetative stage

c. Harvesting stage

Figure 12 View of Kaipad fields

5.2 Cultivation practices in Kaipad

5.2.1 Rice farming in Kaipad

Rice farming is carried out in a purely natural way in

Kaipad relying on the monsoon and the sea tides. Indigenous cultural methods coupled with local saline resistant paddy varieties have made rice cultivation peculiar to this area. In the Kaipad areas, the cultivation is done by mound method. Alternatively, in some locations, saline resistant seedlings are raised in non-saline nurseries and transplanted in the months of June-July to the Kaipad fields[28].

Agricultural operations for cultivating rice begin by mid-April every year. The saline water is drained out completely and the fields are left to dry for about a month. Once the fields are dried, small mounds (*Potta*) of 50 cm in diameter and 60 cm in height are formed. These operations will be over by the middle of May and wait for the monsoon rains. At the onset of the South-West monsoon and as it strengthens, the salinity of the soil in the mounds is washed down by rainwater. As soon as there is adequate fresh water flow in the river, the water outlets of the bunds are opened. From this time onwards, tidal flows are not controlled all through the entire crop season. The fresh river water tides wash down the salinity of the soil. The germinated seeds of a special variety known as *Kuthir* are sown on the mounds. After one-and-a-half months of growth, the seedlings become mature enough for transplantation. The seedlings in the mounds are dug out together with the root soil by male workers and are planted uniformly by women workers in the field after removing the weeds. In this method of cultivation, neither organic nor chemical fertilizers nor pesticides are applied. Thus, it is an eco-friendly farming system. Timely harvesting depends on the intensity and rate of rainfall. If there is too much rainfall or lack of rainfall, there will be crop failure. Further, if rainfall is low, saline water will enter the field during tides and destroy the crop. The crop is usually harvested between the end of September and mid-October.

There were about 2,500 ha of Kaipad rice fields in Kannur District. But now, it has been restricted to about 600 ha. Lack of realization of the potential of high-yielding rice varieties to this rain-fed, shallow lowland is the major reason for the low productivity and shrinkage of Kaipad fields. The traditional cultivars are susceptible to lodging, because of the poor culm strength and excessive culm length, with poor grain qualities like awn on grains, long bold and heavy shattering of grains. Panicles of these cultivars are long but less in the number of grains. However, these cultivars are resistant to all pests and diseases in natural field conditions of Kaipad and the cooked rice is delicious. Sustained and systematic research efforts have resulted in the development of high-yielding rice cultures. As there are increasing demands for organic rice across the world market, development of this type of rice varieties, suited to organic production system, is the need of the hour. A major reason for farmers from the Kaipad area to move away from rice cultivation has been unfavorable characteristics of locally available cultivars[29].

5.2.2 Prawn filtration

After the paddy harvest, the Kaipad fields are used for prawn filtration. With the withdrawal of North-East monsoon in November, the work of strengthening the bunds around the fields begins. The major maintenance work is the reinforcement of the sides of the bund with sticky mud from the river banks and grass and the fixing of wooden sluice gates. When the water in the canal reaches its highest level, the tidal water enters the fields with the maximum force. Prawns and other fishes move into the fields through the tidal currents. The number of young prawns entering the fields depends largely on the force and duration of the current. During the tidal inflow, a conical shaped net with an opening at the end is fixed inside the sluice gate valves. This net lets prawns and fish with tidal flow, but it would not let them out. After the tide, the net is removed and a filter is kept at the mouth of the sluice to prevent prawns and fishes from flowing out from the fields. Water is let in during the two tides. The fields are kept under water for two to three months, allowing the prawns and other small fishes to grow. Rice stubble is a good fertilizer giving rise to a dense growth of algae, upon the detritus of which the prawn fatten. Fish filtration begins and each harvest is called *Ach*, thus in a month there may be two *Ach* having 14 or 15 d of shrimp filtration. On these days, a net is placed at the outlet of the gate valves during ebb flow and prawns are filtered in (*Kandi Koodal*). The summer

filtration continues to mid-April. From then onwards anyone can fish from these private paddy fields. To maximize the harvest, two or three days before mid-April, the owner allows anybody with any technique to fish in the fields, on condition that half the catch shall be given to him (*Kandi Kalakkal*). This open access continues only up to the mound-making. Fish filtration takes place during monsoon too (*Varsha Kettu*), but the catches are very low and the filtration goes on till next summer[30].

5.2.3 Challenges in Kaipad

• **Diversification:** Cultivators' interest in continuing rice cultivation has declined owing to the high wage cost and scarcity of hired labor and the lack of family labor in cultivation. Diversification of economic activities has allowed labor shift from agriculture to non-agriculture.

• **Impact on livelihood:** Though the income from prawn culture has compensated the loss in Kaipad farming to a limited extent, a section of cultivators is keeping their land fallow, thereby causing the spread of mangroves. This combined with the spread of commercial aquaculture has been exerting intense pressure on the Kaipad ecosystem. The degradation of the resource base has affected adversely the livelihood.

• **Development of high yielding varieties:** High-yielding rice varieties suitable to Kaipad rice tracts have not been developed yet. Development of varieties, having high yield, medium height, tolerance to salinity and lodging, favorable grain and cooking qualities, non-shattering and awnless, is a demand of the farmers of this area for a long time.

• **Effect on physico-chemical activities:** Physico-chemical characteristics of the wetlands have changed for the worse, due to the solid waste dumped from urban areas, effluents from factories, shrimp farms and coir retting and changes in the natural tidal flushing due to construction of embankments.

•**Stress on wetlands:** A marked difference is observed in the water quality of the backwaters and of the old-growth mangrove forest, as the latter seems to buffer the change in the water quality to a certain extent. Change in water quality also was visible in the coir-retting pits and the stagnant parts of backwaters. Increase in the spatial extent of the modern shrimp farms was also remarkable which exert considerable stress on the wetlands.

• **Reclamation of lands:** Construction of ponds and reclamation of wetlands for establishing modern farms have not only encroached into the common property resources but have created havoc through bringing about massive land use changes as well. Such altered land uses do not seem to be sustainable in the long run, apart from the fact that they are alienating the local population from the life support systems of the area[31].

6 Conclusions and suggestions

The wetlands of India, particularly in Kerala are currently subjected to acute pressure owing to rapid developmental activities and indiscriminate utilization of land and water. The major issues faced are mainly related to pollution, eutrophication, encroachment, reclamation, mining and biodiversity loss[32] and are summarized below.

• **Impacts on population, economy, ecosystem diminution of bioresources:** Infrastructural and township development has largely destroyed the biodiversity in the area[33].

• **Obstruction to navigation:** Excessive weed growth due to eutrophication leads to higher rate of siltation resulting in shallowing of a wetland.

• **Decrease in agriculture production and productivity:** The agricultural land has considerably reduced because of the conversion and reclamation of the low lands and other wetland areas, which also amounted to reduction in food production. The productivity is also reduced due to erosion and loss of fertility due to pollution.

• **Scarcity of potable water:** Reduction in the ground water recharge and depletion of ground water resources is one of the major impacts of wetland conversion and reclamation.

•**Flood and drought:** The reclamation and conversion led to excess flooding of the area during monsoon. Choking of main drainage channels augmented siltation, thus affecting drainage capacity of channels.

• **Aesthetic value depletion:** Due to encroachment, reclamation and waste dumping activities, the aesthetic

value of the lands are highly affected. The eutrophication and the pollution problems also have much aesthetic impacts, which affect the tourism sector.

The paddy farm sector in Kuttanad is on the verge of serious crisis and farmers are facing a host of problems like the non-availability of required number of laborers, declining profitability of the crop, militant trade unionism, slow pace mechanization, lack of easy credit and proper marketing facilities, recurring crop failures and uneconomic size of holdings. The State Government had appointed several commissions to study the system and to find out appropriate remedial measures for its restoration. Kuttanad Development Authority was constituted for the betterment of paddy cultivation. There is a timely shift from product based strategy to resource based strategy. For the development of the paddy farm sector, there should be (1) effective measures to control floods and salinity ingress, (2) more scientific planning and management in paddy cultivation, (3) implementation of sub-soil drainage system, (4) measures for the adequate supply of HYV seeds, (5) moderation in the use of chemical fertilizers and insecticides, (6) mechanization of farming activities, and (7) diversification of crops to supplement paddy farmers' income.

In Pokkali areas, several factors like lack of production and harvesting incentives, high cost of investment and low yields in Pokkali rice and the shortage and high cost of labor have favored shrimp culture over traditional rice-shrimp rotational cropping system. The traditional landowners are trying to increase their incomes and government is trying to manage for both sustainability and economic growth, where the balance has to be restored. State Government has put forward regulations like the Kerala Land Utilization Order and the *Punja* act to conserve the Pokkali system. Sustainable usage of land and making it available for all the use is the present need of the hour.

The problems faced by the Kole lands are reclamation of land and change in land use pattern. The paddy fields are being converted into high cash yielding plantations. Acidity, salinity, poor drainage and presence of toxic salts are the characteristics of the Kole lands. Thus, the cost of cultivation in these lands is quite high. The group-farming method of cultivation followed in Kole lands facilitates the use of agricultural machinery on a profitable basis for tillage, transplanting, harvesting, and threshing.

The areas under Kaipad cultivation got reduced to a greater extent due to the recent increase in salinity even during monsoons, due to the structural modifications across the river basin. The constraints on the sustainable use of the wetland could not be resolved as the political mediations could not affect any structural changes in agriculture. Collective action could alleviate the socio-economic inequalities that existed in an earlier period and create more equitable society.

With the rising population, pressure on land for agriculture, aquaculture, urban expansion too has increased. As a result of denuding, polluting, draining, filling, etc., these water-logged areas have been under severe threat. Keeping biodiversity under public good has been cited as one of the reasons for the steady degradation. Ensuring community participation and decision making at all levels and local vigilantism with the involvement of Local Governments and NGOs may help in the effective implementation of the Management plans.

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