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Flood Mitigation and River Pamba in Kerala– Insights and Measures with Special Reference to Thottappally

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Abstract

Pamba River in Kerala, in addition to its cultural and historical significance, enriches the districts of Pathanamthitta and Alleppey. Kuttanad, the rice bowl of Kerala, is dependent on this river to fulfil the paddy demands of Kerala. Pampa River wreaked havoc during the floods of 2018 and 2019 in and around the regions of Thottappally. The Thottappally spillway acts as a two-way gateway between the Vembanad Lake and the Arabian Sea. In spite of this the Kuttanad region and the areas around Thottappally has always been at the receiving end during rains, both seasonal and unseasonal. In light of these proper mechanisms and measures must be in place. Also, preparedness to meet the situation arising out of greater inflows is essential. This paper throws light into various issues associated with flooding at Thottappally and gives suggestions to mitigate losses in future.

Keywords: Kuttanad, Vembanad Lake, Paddy cultivation, Monsoon, Holland

1. Introduction

Flooding in Kuttanad and its adjoining areas is a regular phenomenon. It will be more appropriate to use the term waterlogging instead of flooding here. Due to its low elevation, Kuttanad is naturally prone to floods. Thottappally spillway was opened in 1955 with the intention of spilling the excess water flowing out from Kuttanad region into the Arabian Sea. The spillway after commissioning was found capable of spilling only 600 cubic meters of water per second compared to the intended discharge capacity of 19,500 cubic meters per second. In addition to this, the Thanneermukkom bund was constructed to act a barrier to prevent sea water from entering Kuttanad during paddy cultivation season. Kuttanad is one of the very few regions around the world were paddy is cultivated below sea level.

The rice bowl of Kerala, Kuttanad has been in the limelight every time monsoon vents its fury. For Kuttanad these waters are both a boon and bane. A delicate balance between submerging under the floods and remaining dry otherwise is a tight rope walk for the local community who rely on paddy cultivation and fish harvesting for their livelihood. Four rivers namely Pampa, Manimala, Achankovil and Meenachil join the Arabian Sea in and around Thottappally and Thanneermukkom. In addition to this, Muvattupuzha river merges into Vaikkom Lake near Thottappally spillway. The Vembanad Lake sprawling across the regions between Thottappally and Thanneemukkom gets more than enough water it can store during monsoons as seen recently. In light of the floods that happened during 2018 in Kerala followed by the one in 2019, this study examines various facets of flooding in Kuttanad with focus on Thottappally. Also, flood mitigation measures are recommended with a futuristic view.

Kuttanad

Spread around the districts of Alappuzha, Kottayam and Pathanamthitta, Kuttanad is the famous paddy producing region of Kerala. One of the few places below sea level in the world where people dwell in large numbers and cultivate paddy, Kuttanad is epitomized by its scenic beauty as well as the eternal water logging. This region is characterized by altitudes ranging from 1.2 meters to 3 meters below sea level. The paddy cultivation here and the culture that has evolved around the Vembanad Lake is world famous. Kuttanad region is broadly demarcated as: (a) Lower Kuttanad, (b) Upper Kuttanad and (c) North Kuttanad.

This broad below-sea-level polder-farming-system located around the Vembanad Ramsar site is the second Globally Important Agricultural Heritage System (GIAHS) of the Food and Agricultural Organization (FAO) in South India. Continuous application of diverse agrochemicals in the paddy fields and leakage of diesel and engine oil from the intensive operation of tourist diesel-boats in the water bodies resulted in excessive accumulation of toxic residues in Kuttanad. The fish and other aquatic biodiversity-wealth of Kuttanad have been destroyed and the farming remains highly uneconomical. Therefore, the Globally Important Agricultural Heritage System (GIAHS) title of Kuttanad is an opportunity to regain its lost ecological balance (Jacob *et al.*, 2018).

This wetland is famous for paddy cultivation where the paddy is cultivated in two types of polders viz, Padashekaram which are naturally formed polders due to deposition of sediments in this wetland, and Kayal Nilams which are reclaimed land by human effort from the Vembanad backwaters locally called Kayals. Kuttanad has constantly been hogging limelight in recent times largely due to the floods that threw the daily life of local

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community into disarray during 2018 and 2019. To enable cultivation more than once during a year many measures were taken including construction of the Thottappally spillway as well as the Thannermukkom bund (Chandran and Purkayastha, 2018).

Rivers in Kuttanad

Pampa River: The 176 kilometres long River Pampa is inextricably interwoven into the culture and history of Kerala. The third longest river in Kerala, Pampa nourishes several areas of Pathanamthitta and Kottayam districts in addition to watering Kuttanad, the rice bowl of Kerala. The Pampa basin is flanked on the east by the Western Ghats and on the west by the Vembanad Lake and the Arabian Sea. Along with Manimala River towards its northern boundary and Achankovil River on its southern side, Pampa basin is spread over an area of 2235 square kilometres and fulfils the water and electricity requirements of Kerala to a large extent. It empties into the Arabian Sea through Thottappally spillway and Vemband Lake at Mullappally in Alleppey district. Pampa River is also interconnected with numerous waterways in Kuttanad. Originating from Pulachimalai hills in Peerumedu, Pampa is harnessed by major dams such as Pampa, Kakki and Moozhiyar along with other smaller dams that are part of Sabarigiri hydroelectric project.

Manimala River: This 92 Kilometer long River originates from the Muthuvara hills in Western Ghats. The Manimala River was previously considered as a tributary of Pamba River. Now with the advent of Google maps and accurate location-based mapping techniques this notion has been corrected. Actually, Pampa branches into the Manimala River at Kuthiathode and joins Manimala River at Kallunkal. After this, Pampa again branches out from Manimala River at Nedumpuram enriching several areas of Kuttanad like Edathua, Champakulam, Nedumudi and Kainakary before merging in the Vembanad Lake.

Meenachil River: This River originates from several streams stemming from the Western Ghats. The 78 Kilometer long Meenachil River flows through Kottayam district touching places like Poonjar, Teekoy, Erattupetta and Pala. Draining into the Vembanad Lake at the famous tourist destination, Kumarakom located near Thaneermukkom bund Meenachil River adds to the water resources of this region.

Achankovil River: Achankovil River owes its origin to Rishimala, Pasukidamettu and Ramakaltheri rivers and meanders its way through 128 kilometers before its tryst with River Pampa. Intricately linked into the socio-cultural ethos of Pathanamthitta district, Achankovil River is a tributary of the legendary Pampa becoming one with it at Veeyapuram near Thottappally. The river is named after the forest area of Achankovil in Kollam district where it originates.

Muvattupuzha River: This River, which is about 121 kilometers in length is a major river in Ernakulam district. This river is formed out of the union of three rivers namely Thodupuzha, Kaliyar and Kothamangalam. These rivers meet just upstream above the Moovattupuzha Bridge. The name Muvattupuzha has its origins from the confluence of these rivers. After the confluence, the river is known as the Muvattupuzha River. It then flows towards south-west as a single river before joining the Vaikkom Lake.

The four rivers namely Pampa, Manimala, Meenachil and Achankovil empties in Vembanad Lake while watering the low laying Kuttanad region. In addition to this the Muvattupuzha River entering into the Vaikkom Lake also adds to the inflow in this region. The sprawling Vembanad Lake has only two openings into the Arabian Sea. One of them is the Thottappally Spillway and the other is the Thannermukkom bund. Both these structures were built to prevent seawater from entering Kutttand during high tides. This enabled the local farming community to utilize this mineral-enriched low laying river basin for paddy cultivation.

Thottappally Spillway

Constructed during 1955, Thottappally Spillway plays a critical role in creating a pathway for spilling the excess water flowing into this region from the Pampa river basin. During monsoon, sea water rises hindering the flow of water into the Arabian Sea, resulting in flooding in Kuttanad. The opening of shutters of the spillway based on rise and fall in water level is critical for the smooth flow of water. Also care has to be taken to ensure that too much saline water does not seep in. Before the construction of Thottappally spillway, seawater used to enter Kuttanad without any hindrance during high tide.

During earlier days due to this only one crop was possible during a year. This was possible only when tides were low. The farmer community of Kuttanad were at the mercy of elements of nature and their livelihood was destroyed many a time during monsoons and when sea level rose. This prompted the construction of Thottappally Spillway. A Souvenir was released during the opening of the spillway, bridge and the regulator. According to this document, it takes a very long time for the monsoon floods that engulf Kuttanad to subside. From December onwards the saline water enters Kuttanad region making it unfit for cultivation. During construction at the site, it was noticed that the place was once afforested. Further, during piling hard clay bed was encountered which shows that this area was once under sea. According to the document, the spillway was constructed using 40 shutters, each weighing about four tonnes.

Due to the accumulation of floodwaters from the river systems in Kuttanad water level used to rise beyond manageable limits soon after the onset of the southwest monsoon. The entire low-lying areas of the region used to remain flooded till the end of north east monsoon making it impossible to raise a second crop during the autumn season. Detailed hydraulic surveys conducted from the early thirties had shown that this problem could be mitigated by diverting the floodwaters directly to the Arabian Sea at the extreme south of the flood limit itself. Accordingly, the construction of a spillway was started in 1951 at Thottappally located 20 kilometers south of Alappuzha town.

The maximum monthly dispatch of floods entering the Kuttanad region during the monsoon months was estimated as 69000 cusecs, and the spillway was designed to discharge more than 90 percent of it directly to the sea. However, while designing the spillway the problem of piling up of water due to the rising sea level during the

Fig. 1. Thottappally Spillway, Kerala

monsoon months and the consequent formation of the sand bar on the seaward side of the spillway was not taken into account. Therefore, after the spillway was completed in 1955, the realized capacity of it is found to be less than one - thirds of the estimated capacity and hence fails to serve its purpose to some extent (Thomas, 2002).

The Thottappally spillway shown in Fig. 1 was constructed in 1955, as part of Kuttanad development scheme for relieving flood condition in Kuttanad, by diverting flood waters of Pamba, Manimala, Achenkovil and Meenachil directly to the sea. Though the original discharge capacity of the spillway was about 1812 cumec, it is reported that at present the average maximum discharge passing through the spillway is limited to 630 cumec, which is almost 1/3rd of the design capacity of the spillway (SRF Report, 2007).

The Holland Project

The construction of permanent outer bunds around the R Block kayal lands under the R Block-Holland Project that was started in 1961 is a landmark in the history of paddy cultivation in Kuttanad. The embankments built earlier as part of reclamation were made of mud and were not strong enough to withstand the incessant wave action. Most of them were submersible under floodwaters during the monsoon months. Under the R Block-Holland Scheme permanent and non-submersible bunds that stood six feet above the MSL with a top width of ten feet and a total length of 10.4 kilometers were erected around the R Block kayal lands (Thomas, 2002).

Thannermukkom Bund

In order to supplement the Thottappally spillway a bund was envisaged at Thanneermukkom in Alappuzha district. This is a salt water barrier designed as part of the Kuttanad Development Scheme to prevent salt water intrusion into Kuttanad region spread across Vembanad Lake between Thanneermukkom on west and Vechur on the east. Even though Thanneermukkom Bund was constructed in 1974 it became functional only in 1976. The local community fishermen have raised many environmental concerns regarding this construction. The main issues pointed out being destruction of ecological balance in this region affecting fish breeding and uncontrolled growth of water hyacinth, an invasive water plant. Thaneermukkom bund has a total of 62 shutters.

From the early days of reclamation, destruction of Puncha crop due to the ingress of saline water had been a recurring phenomenon in the kayal lands of Kuttanad area. Thanneermukkom saltwater barrier was envisaged to mitigate the problem of saline water intrusion into the Kayal lands located in the south of Thanneermukkom during the summer months when the freshwater inflow of the feeder river systems becomes weak.

The project, in addition to protecting the summer crop from water salinity also aimed to facilitate a second crop soon after the Puncha season. The Barrier is built across the Vembanad kayal connecting Vechoor in the east to Thanneermukkom in the south. Every year regulators of the Bund are lowered in December to prevent the entry of saline water into Vembanad Lake and remain closed till May when the discharges from feeder rivers improve with the pre-monsoon rains. After the construction of this barrier it is possible to raise a second crop in most of the Puncha lands (Thomas, 2002).

Reasons for Flooding in Kuttanad

Torrential rains over a long period resulted in massive inflow into Vembanad Lake, causing destructive floods in 2018. To a smaller scale, it reoccurred during 2019. Kuttanad due to its low elevation will remain water logged no doubt. However, mitigation measures have to be taken at the two outlets to the Arabian Sea from the Vembanad Lake urgently. Even though the Government has certainly taken steps in the right direction, the problem can be addressed only through sustained efforts since there is no permanent solution in case torrential rains occur again. Climatic changes occurring dramatically at regular intervals around the globe, especially due to global warming have resulted in rising sea levels. Kuttanad is becoming more and more vulnerable to floods due to the above factors. This, coupled with its unique geographical positioning, Kuttanad's future is certainly not rosy.

Toward the end of the paper, some mitigation steps are suggested which will help in alleviating the effects of similar natural calamities that might occur in future. When nature vents it fury, man is rendered helpless as seen from the aftermaths of such disasters across the globe. Unpredictable nature of events such as floods and its continued reoccurrences not only destroys life and property but might wipe out an entire culture. Hence preparedness and proper management mechanisms must be in place before the calamity strikes. Increased frequency of floods and consequent losses arise from decreasing floodplain area including the Lake. The Thottappally Spillway (TSW) and the leading channel engineered to reduce the flood intensity in much of the Lower Kuttanad and the Lake area is declining over the years in its flood regulation capacity due to poor maintenance and lack of coordinated action on its operation. Farmers of Purakkad Kari in Kuttanad, where paddy is grown in 3,500 ha during monsoon season, are facing brunt of this decreased flood flow capacity and inefficient management of spillway. Measures recommended include modernization of TSW, deepening and side bund protection of leading channel and improved management of spillway operation (SRF report, 2007).

Four major west flowing rivers namely Achenkovil, Pamba, Manimala and Meenachil drain directly into the southern part of Vembanad Lake while a southern branch of Periyar (further north of Muvattupuzha) drains into Cochin Kayal and finally into the Arabian sea through Kochi outlet. The Vembanad Lake is bordered by Alappuzha (Alleppey), Kottayam and Ernakulam districts of Kerala covering an area of about 200 sq. km and extending 80 km in a NW-SE direction from Munambam in the north to Alleppey in the south. The width of the lake varies from 500 m to 4 km and the depth from 1 m to 12 m (CWC Report, 2018). Table 1 shows the rainfall and runoff in the above four rivers during the period 15 August to 17 August during the 2018 floods. Manimala, Meenachil, Pamba and Achenkovil flow into the lake south of Thanneermukkom, while the Muvattupuzha River flows into the Cochin backwaters north of Thanneermukkom barrage. Kuttanadu is a marshy delta in the southern part of the lake, formed by four river networks namely, Pamba, Manimala, Achankovil and Meenachil together with the backwaters in and around the Vembanad Lake. Large parts of the vast estuary lie below the sea level up to a depth of about 2.5 m, waterlogged for most part of the year subject to flood and inundation during the monsoons and saline water intrusion during the summer months. The Vembanad Lake was declared as a Ramsar Site in November 2002. (CWC Report, 2018). The water carrying capacity of the system is reported to have reduced to an abysmal 0.6 BCM from 2.4 BCM as a result of land reclamation (Planning Commission Report, 2008). The measured water levels from satellite imagery and DEM for the region during 2018 floods indicate that low lying areas in the coastal plains of Kuttanad and the Kole lands of Thrissur had a rise of water up to 5 m and 10 m, respectively which is quite high by any standards (Vishnu *et al*., 2018).

Lessons to be learnt from Holland's defences against North Sea

Holland (The Netherlands) is one the leading economies in the world that fought its way to the top by fighting the North Sea. The sea barriers erected by this country against the raging North Sea are engineering marvels. From time immemorial North Sea has ravaged the coasts of Holland causing innumerable miseries in terms of loss of life and property. Since the floods of 1953 when thousand lost their lives, flood control is top among all agendas of the Government here.

Dykes and other man made barriers were used to control the incoming sea waters into the low laying land. The basic problem face by Holland was its low elevation. More than one thirds of its land is well below sea level. The master plan was based on a state of the art dam with removable gates that were hollow and with the ability to float. They could also be removed as the situation required. Fishes could swim freely through these gates which helped keep the environment more or less the same and stable. When a storm surged in, the gates will get quickly filled up with water allowing it to sink and thus prevent the sea from rushing in. This man-made fortress has saved millions of people from floods. Massive pillars each 30 to 40 meters tall and weighing around 18,000 tons keep the structure in place. This fantastic structure extends over 3 kilometres.

While dykes kept out the North Sea, windmills were used to pump out water over a period of 40 years. The process continues even now, the only difference being that modern technology is being used replacing dykes with computer controlled barriers and state of the art pumps. They have spent billions to make this possible. An elaborate plan called Deltaplan or Delta works was envisaged to combat the ever increasing fury of the North Sea. There are over 3700 km long dykes and dams in Holland.

Rotterdam, one of the busiest sea ports in the world, is well protected by gigantic man-made movable arms that close in during storms thus preventing flood waters entering the port. This structure is considered the biggest robot made ever. The biggest mobile barrier in the world, the Maeslant storm surge barrier, was built to protect the Dutch city of Rotterdam from a one-in-10,000-year storm. It is part of the massive investment the Dutch are making to protect themselves in a new era of rising sea levels.

Table 1. Rainfall and runoff in Pamba, Manimala, Achankovil and Manimala river systems up to Vembanad Lake

River	Catchment Area (in Sq.km)	Rainfall depth 15 Aug 2018 (1 day)	Rainfall depth 15 - 16 Aug 2018 (2 days)	Rainfall depth 15 - 17 Aug 2018 (3 days)	Runoff depth 15 Aug 2018 (1 day)	Runoff depth 15 - 16 Aug 2018 (2 days)	Runoff depth 15 –17 Aug 2018 (3 days)
Achankovil	1359	122	231	329	124	235	336
Pamba & Manimala	2656	173	382	517	346	762	1030
Meenachil	820	146	327	437	90	201	268
Total	**4835**	**441**	**940**	**1283**	**560**	**1198**	**1634**

Kerala and Kuttanad in particular with focus on Thottappally can take a leaf out these great engineering feats of Holland. Luckily for Kerala the inland waters have natural barrier against the sea. Only few openings like the Thottappally give direct access for sea water to enter. State of the art technology in engineering will hold the key to successful management of flood waters in Kuttanad, Constant monitoring and a will power to sustain the efforts will undoubtedly give a holistic solution to the floodwater problems faced at Thottappally.

2. Findings

Waterlogging in Kuttanad is a familiar situation to the local community. However reoccurrence of floods is increasing alarmingly. Kuttanad and adjoining low lying areas of Alleppey due to their geographical local and elevation are flood prone naturally. Recent monsoons and its aftermath points to immediate and regular mitigation steps to be taken to cope up with similar situations that could occur again. The Four rivers namely Pampa, Achenkoil, Manimala and Meenachal that merge into the Arabian Sea in and around Thottappally are major rivers with heavy discharge especially during monsoon. The Thottappally spillway and Thaneermukkom bund are critical in reducing flooding of Kuttanad and adjoining areas in spite of the ecological concerns voiced by the local community.

3. Recommendations

Throughout the year constant monitoring of sea level in relation to the inflow from rivers has to be done with the help of state of the art technology. The sand and silt from the channel leading to sea has to be removed at regular intervals. Depth of the channel has to be assessed at regular intervals through reliable methods since silt accumulation is high. A special team of experts in association with local community members should visit the place at regular intervals to ensure that all flood mitigation steps are meticulously and systematically executed throughout the year. Trained personnel posted at Thottappally should be in constant touch with experts in marine geology, sea and ports and oceanography so that mitigation strategies can be devised as the situation demands. The silt and sand accumulated in dams in rivers that flow into this area have to be removed at regular intervals. This will increase the capacity of the dams. If possible steps can be taken to pump out water from low lying areas using technology from Holland as and when inflow increases. The removal of sandbars at Thottappally based on scientific study as per the situation in hand will help in mitigating floods. The expertise of engineers of Holland who have created the world's biggest barriers against sea can be sought. Computer-controlled flood defence systems should be implemented, which will monitor water inflow right from the Western Ghats to outlets at Thottappally.

4. Conclusion

There is no doubt that the rising sea levels due to climatic changes spell disaster for low lying areas around the world. Thottappally and adjoining areas of Kuttanad will face more floods in future. Based on the finding and suggestions formulated from the study, it is clear that mitigation strategies may be adopted in the Pampa basin at the earliest. State of the art technologies with the aid of remote control automatic systems will have be installed. Constant monitoring using all expertise available at hand will certainly help preserve this Ramsar site. Ecological imbalances can be overcome if the saltwater intrusion is kept optimal. Also, flood mitigation mechanisms when inflow is high during rains should be precise. Placing well-trained personnel backed with the right technology will pave the way for a safer and ecologically stable future for this region.

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