ROLE OF FLOOD CONTROL DAMS IN MANAGING EXTREME CLIMATIC EVENTS : A CASE STUDY OF KERALA'S PERIYAR BASIN

K.A. JOSHY, SOUMYA R CHANDRAN AND SUDHEER PADIKKAL
Water Resources Department of Government of Kerala State, India

ABSTRACT

Increased frequency of extreme climatic events indicates climate change. In this paper, we are investigating the role of flood control dams in managing extreme climatic events with a case study of Periyar basin in Kerala. Scientific analysis of Kerala floods in 2018 and 2019 have already proven that these floods were not dam induced. Rather, the role of flood control dams in managing similar extreme events are increasingly recognized. The master plan of Kerala's Periyar basin, which witnessed extreme flooding in 2018, had proposed two more dams in two different tributaries of this river. However, these dams were not constructed due to several reasons including the issues of environmental sustainability. Revisiting of the master plan of Periyar in the context of extreme events is attempted in this paper. It reiterates that these dams can be constructed and operated without compromising the environmental sustainability and they can be effective tools for managing extreme floods.

1. INTRODUCTION

Extreme climate variations are significantly altering the structure and functioning of many ecosystems. Climate-driven extreme weather events, such as floods, droughts, heatwaves and cyclones, cold waves, devastating thunder clouds, cloudbursts and intense cyclonic storms have been occurring frequently over the globe and becomes a huge humanitarian challenge. Significant advances in the scientific understanding of climate change now makes it clear that there has been a change in climate that goes beyond the range of natural variability. Modern land use practices, increased development in flood plains and destruction of natural areas have left the landscape less able to accommodate heavy rainfall, increasing risk of floods and exacerbating their impacts. With rising global temperature due to increased heat trapping emissions, more water evaporates from the land and oceans. Warmer atmosphere holds more water vapour and when it rains, there is a higher potential for heavy rainfall, which is the main cause of inland flooding. The damage caused by climate change will increase as temperatures rise, and the Intergovernmental Panel on Climate Change (IPCC) warns that it will "disproportionately affect disadvantaged and vulnerable populations through food insecurity, higher food prices, income losses, lost livelihood opportunities, adverse health impacts, and population displacements" (IPCC 2014). Climate change threatens to create a vicious cycle for the world's poor, as further warming pushes more people into poverty, increasing their vulnerability to climate impacts. Nowhere is this clearer than in relation to climate-driven extreme weather events, such as floods, droughts, heatwaves and cyclones, which present a huge humanitarian challenge.

Kerala State lies along the coastline, to the extreme south west of the Indian peninsula, flanked by the Arabian Sea on the west and the mountains of the Western Ghats on the east. Though Kerala state is blessed with 44 rivers, it is not a water rich state. The extreme rainfall events during monsoon and severe drought in summer months causing acute drinking water shortage are becoming repetitive. Flood and landslides are the most common natural hazards in Kerala. In August 2018, a devastating flood struck Kerala, causing significant damage to life and property. Kerala Floods of 2018, as it is known in the print and social media has discussed it across its breadth and depth. Recently, the UN Secretary General referred to the Kerala floods, among other natural disasters across the world, to highlight the urgency of the climate crisis and the need to step up efforts to reverse course on climate change. The extreme rainfall and the very high population density made the deluge significantly affecting a population of 1.2 million. About 400 persons lost their lives and the basic infrastructure facilities were seriously damaged (PDNA 2018).

The state of Kerala is now on a massive mobilization drive to rebuild a new Kerala. RKI (Rebuild Kerala Initiative) focus on sustainability principles suggested in the Post Disaster Needs Assessment (PDNA) study. Integrated Water Resources Management (IWRM) based on principles of "room for river" and "living with water" has been identified in the PDNA as one of the four pillars of recovery strategy. In Kerala, the concept of Integrated Water Resources Management (IWRM) is well known but, yet, not adopted in its water resources management policies, planning and programmes. Robust institutional arrangements for the integrated river basin management, as suggested in the PDNA, does not exist now in Kerala. Therefore, an institutional setup, 'River Basin Authority of Kerala' (RBAK), for the successful implementation of recovery strategies suggested in the PDNA and for carrying forward IWRM programmes is being thought about with high level administrative and political support and is ought to be embedded in a long-term vision of Kerala's sustainable development.

But in Kerala it looks like climate change induced floods are becoming an annual affair. Following the 2018 deluge, the state was struck with devastating floods again in August of 2019, due to climate change, population pressure and unscientific land utilization. The present priority of the State is the development of an Integrated flood management approach aiming efficient use of flood plains and coastal zones, while minimizing the loss of life and impact on livelihoods and assets through protective measures. IFM is a paradigm shift from the conventional, fragmented and localized approach calls for the use of resources of a river basin as a whole, employing strategies to maintain or augment the productivity of floodplains (WMO 2009). Being a dynamic notion, it includes several emerging issues such as risk management, urban floods, climate variability and change and adaptive management. Moving towards integration of ecosystems, disaster risk reduction and adaptation to climate change is the need of the moment (IUCN 2013) and the State has set a goal for combining Engineering solutions and mainstreaming an Ecosystem based Disaster Risk Reduction (Eco-DRR) into development, as identified in the PDNA study.

Considering an integrated approach for flood management and in align with basic principles of IWRM and following the concept of 'Room for River project' of the Netherlands, the State is envisaging to provide more space for the water body so that it can manage extraordinary high-water levels during floods. Apart from the same, hard engineering solution of Detention reservoirs, without any environmental implications are also in the pipeline. This paper broadly highlights one such potential approach for flood control in Periyar basin, which was one among the worst affected during August 2018 floods, through hard engineering solution of Flood Control dams at two locations.

2. AREA PARTICULARS

2.1 Periyar river basin

Periyar is the longest river with largest discharge potential in the State. It has a total length of approximately 244 Km and a catchment area of 5,398 sqkm of which 5,284 sqkm is in Kerala and 114 sqkm is in Tamil Nadu. The basin has an inverted 'L' shape with a maximum width at the intersection. Major tributaries of the river are Mullayar, Cheruthoni Ar, Muthirapuzha, Perinjankutty Ar and Idamalayar, and most of the upstream tributaries flow through deep gorges and steep valleys. At Aluva, the river bifurcates into the Marthandavarma and the Mangalapuzha branches. The Mangalapuzha branch (primary) joins Chalakudy River and empties into the Sea and the Marthandavarma branch (secondary) flows southwards going through the Udhyogamandal area and finally draining into the Cochin backwater system (part of Vembanad Lake). The average annual rainfall in Periyar basin is around 1933 mm. Neelaswaram and Vendiperiyar are the two CWC HO stations located on the river.

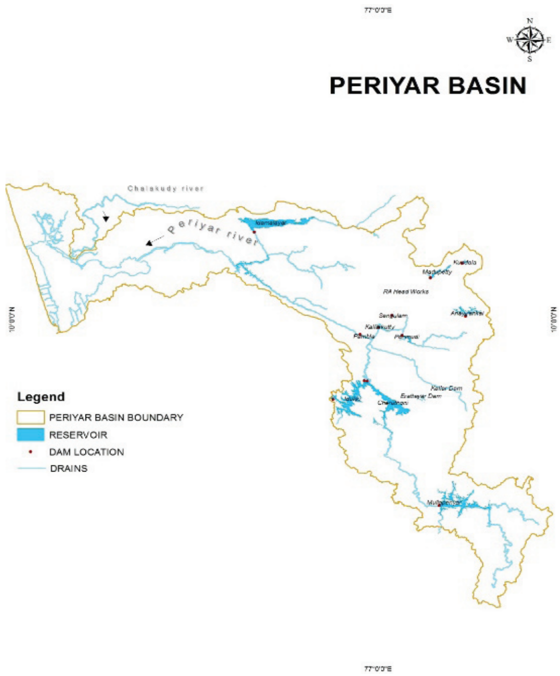

Figure 1 : Periyar River Basin (Including Chalakudy River System)

The stream flow in the basin is heavily regulated by 17 dams and reservoirs and 2 barrages, which are constructed mainly for hydroelectric power generation as well as irrigation, as depicted in Figure 1. Out of this, two major ones are

Idukki and Idamalayar with 1.46 BCM and 1.0 BCM storage capacity respectively (CWC 2018). The water level in the Idukki reservoir, the largest reservoir of the basin, is maintained by three dams, viz. Idukki, Cheruthoni and Kulamavu dams. Among the various dams, the largest dams are the Idukki–Cheruthoni–Kulamavu trio and the Idamalayar. The major irrigation projects in the basin are the Periyar Valley Irrigation Project, and the Idamalayar Irrigation Project. The major inter-basin transfer projects from the basin are the Mullaperiyar Dam (to Vaigai River, Tamil Nadu) and the Idukki Hydroelectric Project (to Muvattupuzha River, Kerala), and minor water transfer to Bharathapuzha river (Kerala) also co-exist in the basin (Sudheer et al. 2019).

2.2 Rainfall analysis

Periyar catchment received continuous rainfall from the beginning of June 2018 and reservoirs of Idukki and Idamalayar had reached almost FRL by end of July. Continuous spell of rainfall had already made the soil of the basin saturated, and the extreme rainfall that occurred in August resulted in higher runoff than normal conditions. The analysis of rainfall data as carried out by Central Water Commission specifies5 that Kerala received about 2346.6 mm of rainfall during 1st June 2018 to 19th August 2018 against the normal rainfall of 1649.5 mm, which was 42% above the normal. During 1st August 2018 to 19th August 2018, total rainfall occurred in Kerala was about 758.6 mm against the normal of 287.6 mm, which was 164% above normal. The average cumulative rainfall of 15-17, August 2018 is about 414 mm for entire Kerala. The consequent cumulative runoff of three days for the entire Kerala (area about 38,800 sq.km) was about 12 BCM (12,000 MCM) for a runoff coefficient of 0.75.

During 15-17, August 2018, the 3-day rainfall depths realised in Periyar, Pamba, Chalakudi and Bharathapuzha sub-basins were 588 mm, 538 mm, 421 mm and 373 mm respectively. Due to severe rainfall from 15-17, August 2018, the gates of about 35 dams were also opened due to extremely large inflow of water in the reservoirs. August 2018 flood in Kerala was due to severe storm occurrences during 8-9, August 2018 and 15-17, August 2018. The storm of 15- 17, August 2018 resulted in heavy flooding in Periyar, Pamba, Chalakudi and Bharatpuzha sub-basins of Kerala5.

Sudheer et al. (2019) had simulated the flow in the basin for different scenarios such as virgin basin, actual floods and dams at various storage levels, for period from 1st August 2018 to 31st August 2018 to represent conditions prevalent within the catchment. The study had identified that reservoir operation could not have helped in avoiding the flood situation and that as the probability of extreme rainfall events of that kind in the month of August in Periyar was very small (0.6%) and any planned operation could not have helped in mitigating floods of such magnitude as the reservoir design might not have considered such events.

Padikkal & Joshy (2019) also had analysed the extreme rainfall event and dam management during Kerala floods of 2018 to investigate the dam safety – disaster management nexus. Major conclusions of the study were that the extreme rainfall event had a return period of 100 years or more and that Dam management did not contribute to the worsening of flood.

3. APPROACH AND METHODOLOGY

Even though Periyar basin houses several water retaining structures, major ones being Idukki and Idamalayar, none of them are designed for flood control. An attempt has been made to identify the ideal location for detention reservoirs/ flood control dams to mitigate damages due to extreme flood events.

Sudheer K P et.al6 had demonstrated that for Periyar River basin, the role of releases from the major reservoirs in the flood havoc was less. It proved that attenuated flood peak due to advance emptying of the reservoir would still be almost double the safe carrying capacity of the Periyar river section at Neeleswaram. Their analysis suggested that reservoir operations could not have helped in attenuating the flood peak as the bulk of runoff to the flooding was also contributed by the intermediate catchments without any reservoirs to control. The simulated and observed peak flows to Idukki reservoir (upstream of PRB) were 2763 and 2532 m3/s respectively. Similarly, the maximum discharge simulated at Neeleswaram was 9965 m^3/s against the measured value of 8800 m3/s. The flood hydrograph without dams (virgin simulation) and the actual flood event (simulation with reservoirs at storage capacity 85% by the end of July 2018) showed reduced peak discharge at immediately downstream of Idukki by 33% and at Neeleswaram by 17%, indicating the positive role of dams in attenuating the flood magnitude. The study also indicated that the major share of the total flood flow in the basin was from Perinjankutty stream (3500 m^3 /s), which is a near uncontrolled tributary, while the controlled releases from Idukki had contributed only 1860 m^3/s.

Based on the comparison of different scenarios of flooding undergone in the study by Sudheer K P et.al6 and data from CWC report5, four different scenarios were selected for comparison.

1. Actual Floods of 2018
2. Virgin scenario (without dams)
3. Idukki & Idamalayar dams being 50% empty
4. With Flood Control dams at two locations

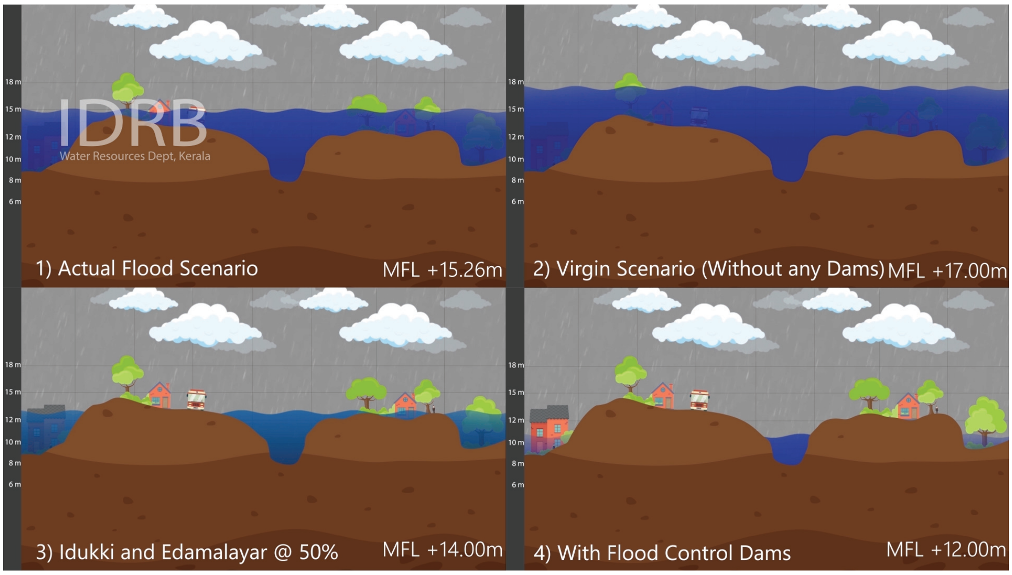

Figure 2 : Inundation at Neeleswaram on comparison of different scenarios of flooding in Periyar

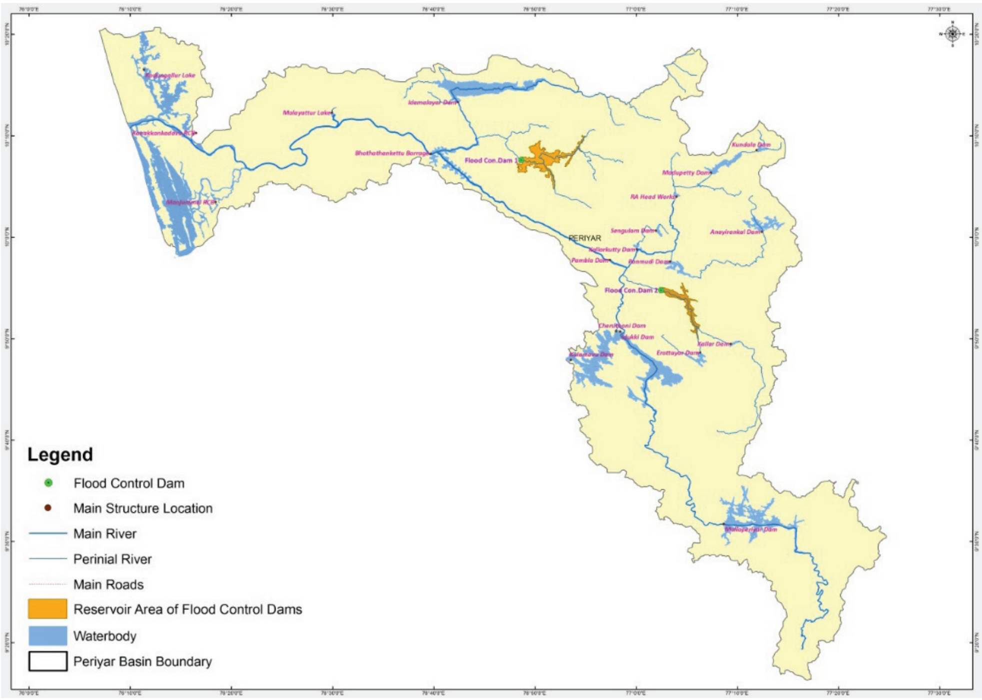

Figure 3 : Proposed location of flood control dams in Periyar basin

3.1 Tentative location of Flood control dams

A potential location for flood control dam is identified as the uncontrolled catchment at the Perinjankutty stream at FRL of 270m, storage of 12 TMC and catchment area of 324 sqkm, while the other one at FRL of 659m, storage of 15 TMC and a catchment area of 390 sqkm, at the join of the downstream of Erattayar and Kallar dams.

Based on the data from the reference studies, the average rainfall recorded on Periyar basin during 15th, 16th & 17th August 2018 were considered. The location considered for the comparison is CWC Station at Neeleswaram and Maximum Flood Level (MFL) in each scenario were computed. From the comparison of different scenarios, it is inferred that there is a considerable reduction of MFL by 3.26m with the introduction of flood control dams at the two locations, as compared to the original flooding scenario.

4. SUMMARY AND CONCLUSION:

This paper has highlighted the flooding situation in Periyar basin keeping in view of the reference study reports. It has also put forward the effect of flood control dams in reducing the flooding situation in the basin. Major conclusions of this paper are:

1. Flood control dams are an engineering solution for management of flooding in Periyar basin

2. On comparison with actual flooding and with the introduction of Flood control dams at two locations, the depth of inundation has reduced by 3.26m based on the observation at Neeleswaram station.

After the Kerala Floods, a Post Disaster Needs Assessment (PDNA) was initiated on September 18, 2018 for a period of three weeks. IWRM is the main platform recommended by PDNA for Rebuilding a Resilient Kerala. It aims to break inter-sectoral barriers to establish a holistic framework for coordination. An integrated approach for management of floods in Kerala basins in alignment with Eco system-based Disaster Risk Reduction is the prime focus of the State. How these flood control dams can be effectively operated to facilitate the required environmental flows during lean months, thereby making them control more sustainable, is a sequel to this study to be taken up.

REFERENCES

CWC. 2018. Kerala Floods of August 2018, Central Water Commission, New Delhi, 2018

IPCC. 2014. Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

IUCN. 2013. Role of ecosystems in disaster risk reduction. Edited by Fabrice G. Renaud, Karen Sudmeier-Rieux and Marisol Estrella. International Union of Conservation of Nature

Padikkal, Sudheer & Joshy K.A, 2018, Dam Safety - Disaster Management Nexus: Lessons learned from Kerala floods. International Dam Safety Conference 2018

PDNA. 2018. Kerala Floods and Landslides: Post Disaster Needs Assessment Report. United nations, Government of Kerala and European Union

Sudheer K P et.al. 2019. Role of dams on the floods of August 2018 in Periyar River Basin, Kerala, Accepted Manuscript in Current Science

WMO. 2009. Integrated Flood Management Concept Paper. Global Water Partnership, World Meteorological Organization