FIFTEENTH KERALA LEGISLATIVE ASSEMBLY

COMMITTEE
ON
PUBLIC ACCOUNTS
(2023-26)

NINETY FOURTH REPORT

(Presented on 28th January, 2026)

SECRETARIAT OF THE KERALA LEGISLATURE
THIRUVANANTHAPURAM

2026

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on

Paragraphs on chapters I, II, III relating to Revenue & Disaster Management, Power, Home and Water Resources Departments contained in the Report of the Comptroller and Auditor General of India on Preparedness and Response to Floods in kerala

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COMMITTEE ON PUBLIC ACCOUNTS (2023-26)
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INTRODUCTION

I, the Chairperson, Committee on Public Accounts, having been authorised by the Committee to present this Report, on their behalf present the ninety fourth Report on paragraphs on chapters I, II, III relating to Revenue & Disaster Management, Power, Home and Water Resources Departments contained in the Report of the Comptroller and Auditor General of India on Preparedness and Response to Floods in Kerala

The Report of the Comptroller and Auditor General of India on Preparedness and Response to Floods in Kerala was laid on the Table of the House on 11th November 2021.

The Committee considered and finalised this Report at the meeting held on 20th January, 2026.

The Committee place on records our appreciation of the assistance rendered to us by the Accountant General in the examination of the Audit Report.

SUNNY JOSEPH,
Chairperson,
Committee on Public Accounts.

Thiruvananthapuram,
28th January, 2026.

REPORT

DEPARTMENTS OF REVENUE AND DISASTER MANAGEMENT, POWER, HOME AND WATER RESOURCES

Introduction

The National Centre for Earth Science Studies (NCESS) estimates[1] that 14.52 per cent of the total area of Kerala is prone to floods. Floods are the most common of natural hazards that affect people, infrastructure and natural environment in Kerala. Incidence of floods in the State is becoming more frequent and severe. While high intensity rainfall causes flooding during monsoons inIntroductions and wetlands over the years have contributed to increasing flood damages. Hence, flood management needs to be accorded high priority in the disaster management profile of the State. The mitigation of damages caused by floods is dependent upon a combination of pre-flood preparedness, operational flood management and post flood review.

Government of Kerala (GoK), in line with the Disaster Management Act, 2005 enacted the Kerala State Disaster Management Rules, 2007 and promulgated the Kerala State Disaster Management Policy, 2010 for holistic disaster management in the State. The Kerala State Disaster Management Authority (KSDMA) under the Revenue and Disaster Management Department was constituted (2007) to lay down guidelines to be followed by the various departments of GoK in the formulation of their development plans and projects such that integrated measures

1 Estimated in 2010 on the basis of multi hazard zonation maps prepared by NCESS

could be taken for prevention of disasters and provide necessary technical assistance for disaster management.

A Performance Audit on 'Preparedness and response to floods in Kerala' covering the period 2014-19 was conducted to assess whether planning and implementation of flood management measures were effective with focus on the floods in 2018.

1.1. Organisational set-up for flood control

The Kerala State Disaster Management Authority (KSDMA)[2] is assisted in the execution of its functions by the State Executive Committee (SEC) which was constituted (2007) by the GoK with the Chief Secretary to the Government as the Chairperson. The Head of the Department of Revenue and Disaster Management, who is the Convenor of SEC and Head of the Department of KSDMA, acts as the State Relief Commissioner.

District Disaster Management Authorities (DDMA) have been constituted in all 14 districts to act as the planning, coordinating and implementing bodies for disaster management and to mobilise resources of all relevant departments at their level. As per Kerala State Disaster Management Plan approved in 2016, the Water Resources Department is the nodal department for preparedness, and the Revenue and Disaster Management Department, for response and recovery in times of flood.

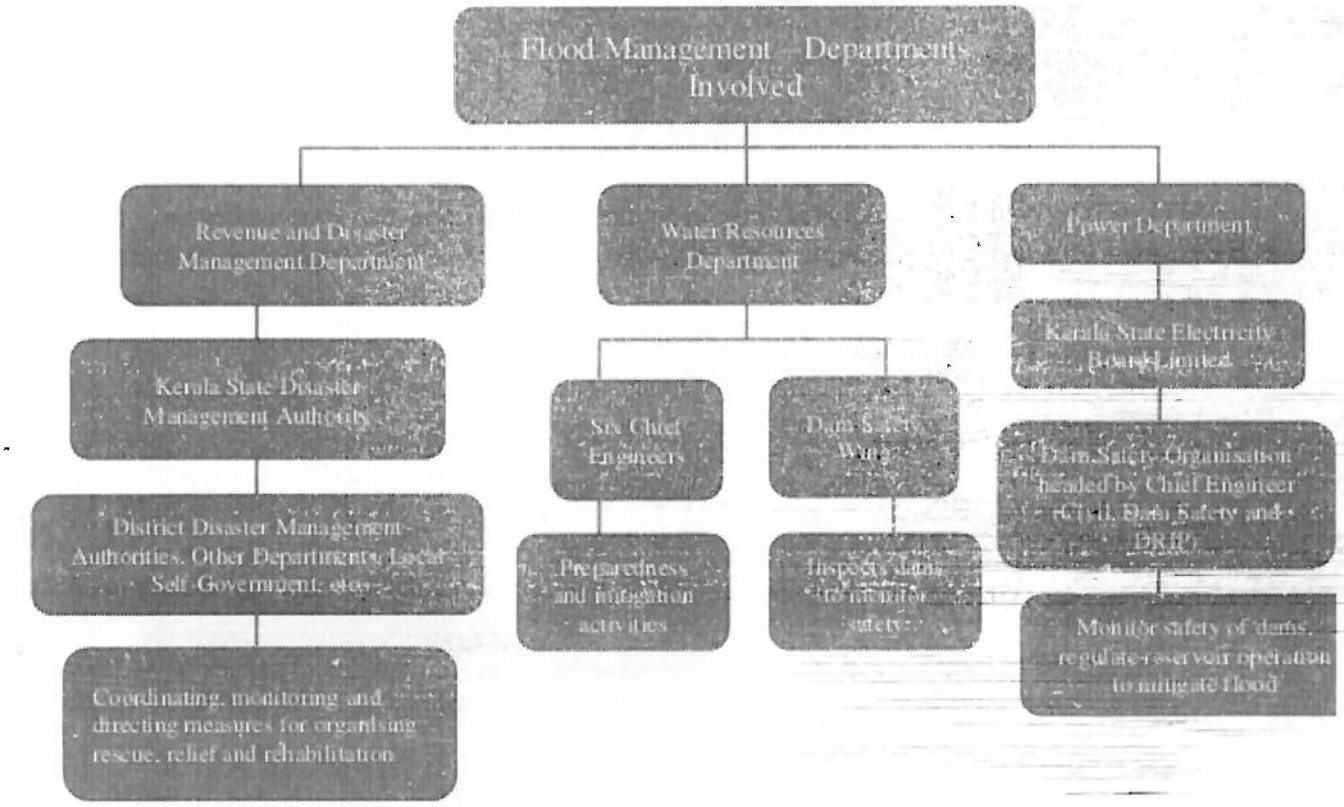
Emergency Operations Centres at the State (SEOC) and district level (DEOC) function under KSDMA and DDMAs respectively, for prompt

2 with the Chief Minister of the State as the ex-officio Chairperson and nine members including the Minister of Home and Vigilance, Minister for Agriculture and Principal Secretary, Revenue and Disaster Management Department forming part of the Authority

assessment and relay of information to facilitate quick response and effective decision making. The Departments of Water Resources and Power, through their subordinate wings/ officers, implement structural and non-structural measures for disaster risk reduction to effectively manage flood scenarios in the State. The organograms presented below depict the organisational set up of disaster management in the State.

Institutional set up for disaster management

Institutional set up for disaster management (contd.)



1.2. Audit Objectives

The Performance Audit was conducted with a view to assess whether

- planning for flood management was comprehensive and effective;
- implementation of measures for management and control of floods was effective;
- preparedness and response to the floods in 2018 was adequate and timely.

1.3. Audit Criteria

Audit observations were benchmarked against the criteria derived from the following documents:

- The Disaster Management Act 2005

- NDMA Guidelines on Management of Floods 2008
- Kerala State Disaster Management Rules 2007
- State Disaster Management Policy 2010
- National Disaster Management Plan 2016
- State Disaster Management Plan 2016
- National Water Policy 2002, 2012
- Central/ State Government Orders, Circulars, Codes, Manuals and Guidelines of KSDMA, other implementing agencies etc.

1.4. Audit scope and methodology

Audit adopted a two-stage sampling methodology for selection of four out of 14 districts (25 per cent) for test check. While Idukki district was judgmentally selected due to the maximum concentration of large dams, the remaining three districts of Alappuzha, Ernakulam and Thrissur were selected through riskbased sampling. Eight[3] Taluk Offices in these four districts (two per district) which were worst hit during 2018 floods were also selected for detailed scrutiny. The detailed list of institutions covered by Audit is given in **Appendix III (1).**

The Performance Audit covering the period 2014-19 was conducted between May 2019 and February 2020 by scrutiny of relevant records of the Revenue and Disaster Management Department and the Water Resources Department in Government Secretariat and the various agencies[4] connected with the management of floods at State/ District/

3 Alappuzha district: Kuttanad and Chengannur; Ernakulam district: Aluva and Paravur; Thrissur district: Chalakkudy and Thalappilly; Idukki district: Idukki and Devikulam Taluk Offices

4 Office of the Chief Engineer, Irrigation department, Dam safety offices, KSEBL/ Irrigation division offices of test-checked dams, offices of Disaster Management Authorities and Emergency Operations Centres in selected districts and Disaster Management sections in taluks.

Taluk/ Village level including the Kerala State Disaster Management Authority, SEOC, Institute of Land and Disaster Management (ILDM), India Meteorological Department (IMD), Kerala State Electricity Board Limited etc. An Entry Conference was held on 18 June 2019 with the Principal Secretary, Revenue and Disaster Management Department, Secretary, Water Resources Department (who was also the Secretary, Power Department) and heads of audited institutions, including the Chairman, Kerala State Electricity Board Limited wherein the scope, objectives, criteria, and methodology of audit including selection of districts for test check were discussed.

On conclusion of audit, Exit Conferences were held with the various Departments mentioned in the Report through video conferencing on different dates as per the Government's request and in the wake of COVID pandemic, during which the audit findings and recommendations of audit were discussed in detail. Additional remarks offered by the Government with respect to the audit findings have been considered in the finalisation of the Report. Exit Conferences with Principal Secretary, Revenue and Disaster Management Department along with the Commissioner, Disaster Management and Member Secretary, KSDMA was held on 18 January 2021, with Secretary, Power Department along with Chairman, Kerala State Electricity Board Limited on 23 January 2021 and with Additional Chief Secretary, Water Resources Department on 02 February 2021[5].

5 Discussion was held with the Executive Director, Cochin International Airport Limited on 29 January 2021.

Audit methodology included scrutiny of records in selected offices, joint field visits with department officers to dam sites, river basins, flood prone areas, flood management structures etc. Audit also conducted a survey of 800 persons affected by flood in the test-checked districts. Audit engaged the Indian Institute of Science (IISc), Bangalore as Consultant to study the Kerala floods of August 2018 from a hydrological perspective. The study area was the Periyar river basin, which covers an area of 5159.71 square kilometres. The Government has communicated its concern over the fact that a simulation study by the Consultant IISc Bangalore has been relied upon for auditing a crisis management period, viz. the floods of August 2018. Audit's response is that the simulation studies by technical experts, though undertaken ex post facto, are reliable as a constructive tool, even for a crisis management situation. In this instance, the exercise has been useful in re-creating the hydrological scenario of the 2018 floods for the purpose of examining whether reservoir operations could have been handled differently with the then available set of data and thus facilitate better preparedness to handle similar challenging situations, that may arise in the future.

1.5. Acknowledgement

Audit acknowledges the cooperation extended by the Department of Revenue and Disaster Management, Department of Water Resources and Department of Power, Government of Kerala in the conduct of the Performance Audit. The co-operation extended by officials of Central

Water Commission, India Meteorological Department, Kerala State Electricity Board Limited (KSEBL), Kerala State Disaster Management Authority, Irrigation Design and Research Board, Dam Safety Organisation, Kottayam, Kerala State Remote Sensing and Environment Centre and District Disaster Management Authorities in Alappuzha, Thrissur, Ernakulum and Idukki is gratefully acknowledged. Audit records its appreciation for the efforts of Prof. P. Pradeep Mujumdar and his team from IISc, Bangalore in submitting a Report on the 2018 Kerala floods. Audit has relied, inter alia, upon the Consultant's study for observations relating to Reservoir Operations and impact of Land Use and Land Cover change, included in this Report.

2. Planning and Capability Building

The Disaster Management Act(DM Act) enacted by Parliament in 2005 envisages a continuous and integrated process of planning, coordinating and implementing measures for disaster management. The Act stipulated that a State Authority shall be vested with the responsibility for laying down policies and plans for disaster management in the State. In Kerala, at the district level, District Disaster Management Authorities were also constituted in September 2008 following the constitution of the State Disaster Management Authority. The KSDMA assisted by the State Executive Committee is responsible for measures to be taken for mitigation, capability building and preparedness by the various departments and to issue such guidelines as may be necessary.

Planning

2.1. Inadequate provision for flood management in the State Water Policy

The Government of India formulated a National Water Policy (NWP) in 1987 which was revised in 2002 and subsequently in 2012. The NWP envisaged and included provisions relating to the management of flood. The NWP 2002 envisaged that States would formulate a Master Plan for flood control and management for each flood prone basin, and provide for adequate flood-cushion in water storage projects as well as strict regulation of settlements and economic activity in the flood plain zones to minimise the loss of life and property on account of floods. The NWP 2012 required operating procedures for reservoirs to be evolved and implemented in such a manner so as to have flood cushion and to reduce trapping of sediment during flood season. It also mentions that encroachments and diversion of water bodies must not be allowed and restoration must be promoted to the extent feasible. NWP 2012 envisages the drafting of State Water Policy (SWP) in accordance with NWP keeping in mind the basic concerns and principles as also a unified national perspective.

Audit observed that as against the NWP, the Kerala SWP, as formulated by the Water Resources Department (July 2008) did not consider the aspect of management of floods in the State. The provisions in the Water Policy of GoI which placed emphasis on preparedness for flood, modernisation of flood forecasting using real time data acquisition

system linked to forecasting model[6], evolving and implementing operating procedures for reservoirs in order to have flood cushion, increasing preparedness for sudden and unexpected floods were not included in the Water Policy formulated by GoK. During the course of the Performance Audit, Audit came across issues[7] such as the absence of legislation to demarcate flood plains, encroachment of water bodies, absence of flood forecasting stations, inadequate desiltation activities etc. Non-inclusion of elements of flood control measures in the State Water Policy was indicative of the relative low priority given to flood management issues possibly because Kerala was not considered a flood prone State until recent years.

The Department of Water Resources replied (November 2020 and April 2021) that though the SWP 2008 does not explicitly provide for flood management/ forecasting, the Department had given emphasis to flood preparedness/ forecasting in the past and 131 rain gauges, 54 river gauge stations and nine fully automatic climatic stations had become operational prior to the floods of 2018. In order to equip the State to contain disasters of similar magnitude as that which took place owing to the unprecedented heavy rainfall, after the 2018 floods, the Government resolved to develop a full-fledged inflow forecasting and flood early warning system under the National Hydrology Project in all river basins with real time monitoring through tipping bucket rain gauge (99 nos.), radar level sensor (56 nos.) and automatic weather stations (13 nos.).

6 Paragraphs 17.2, 17.3, 17.4 and 17.5 of the NWP 2002
7 Paragraphs 2.3, 3.3 and 3.7 and **Appendix III(1)** of this Report

Orders have been issued to develop a single authoritative platform Kerala Water Resources Information System for all water resources related information. The Department stated that these facts indicate that the Government had a functional mechanism with respect to flood forecasting and was quick to formulate measures for real time flood forecasting in the wake of the after effects of 2018 floods. The reply also indicated that a drafting Committee was constituted in November 2017 for formulating a revised SWP, which was reconstituted in January 2021 and the Committee submitted a revised draft of the amended SWP on 05 April 2021. Revised State Water Policy containing the provisions for flood management based on State specific requirements would be promulgated when the new Government comes to power.

The response of the Department confirms the inadequacy of provisions relating to flood management in SWP as depicted in the audit paragraph.

Recommendation 2.1: Government of Kerala may consider revision of the State Water Policy to include aspects relating to flood management, in line with the National Water Policy and after considering the specific requirements of the State.

[Audit paragraphs 1.1 to 2.1 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraphs are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

1. In response to the audit observation concerning inadequate provision for flood management in the State Water Policy, the Chief Engineer, Irrigation and Administration provided a detailed overview. He stated that the State Water Policy, declared in 2008, incorporated various aspects related to flood management, including relevant provisions, precautionary measures, and activities associated with the Disaster Management Committee. It was noted that the State Water Policy was due for revision every ten years. To facilitate that process, a drafting committee was constituted in 2017, which conducted multiple meetings to address the necessary updates. However, during that period, significant challenges came up including the mega floods of 2018 and 2019, followed by the COVID-19 pandemic that impacted the subsequent two years. A draft of the revised water policy was prepared, after discussions with all stakeholders, and subsequently submitted to the Government. Certain deficiencies were identified which were thoroughly reviewed and discussed, and finally a revised draft State Water Policy was submitted to the Government in April 2024. That draft included the comments and provisions highlighted by the Accountant General also.

Conclusion/Recommendation

2. No comments

2.2. Non-preparation of State level Master Plan for water resources development and management

The State Water Policy (SWP) 2008 considered the micro watershed as the basic unit and the river basin as an integrated unit of micro-watersheds. It envisaged preparation of a State level Master Plan for water resources development and management by compiling the status and action plans in each micro watershed, sub-basins and river basins in a hierarchical form. Additionally, Master Plans for the major rivers of

the State were to be prepared which would form the basis of any river-based project. A State Level River Authority was also to be constituted for coordinating all water related activities at the river basin level. A GoI report of the National Commission on Flood had observed as early as in March 1980 that the practice of undertaking flood schemes on ad hoc basis was unscientific and recognized an urgent need for preparing basin-wise Master Plans which would indicate priority of schemes for implementation.

Audit noted that a State Level River Management Authority was yet to be constituted. Non-constitution of the same meant absence of an institutional mechanism for ensuring co-ordination between different implementing agencies and for monitoring prioritisation of works undertaken. The canal work in Cochin International Airport Limited (refer Paragraph 4.3 of this Report) is an example of a case where the State Level River Management Authority could have monitored the prioritisation of the works to be undertaken to prevent inundation of the airport and areas in the vicinity during the floods of 2018.

Audit further observed that during 2014-19, the Irrigation Department of GoK expended ₹178.99 crore for flood control/mitigation works in the State including 273 works at a cost of ₹55.17 crore in the test-checked districts of Thrissur, Idukki, Ernakulam and Alappuzha. Works were also executed under the River Management Fund, Atal Mission for Rejuvenation and Urban Transformation (AMRUT) scheme, Kuttanad Development Scheme and Project Management works. These works

were taken up at different locations, based on the requests from local people, people's representatives and local bodies without being linked to a comprehensive plan for the management of floods. In the test-checked districts, Audit noticed that no survey or investigation was conducted to identify the flood prone/vulnerable areas for prioritising the works to be undertaken.

Audit was informed (March 2020) that the Master Plan of only one river[8] viz. Chaliyar besides two[9] of the five tributaries of the Bharathapuzha River had been completed. Thus, Master Plans of 42 out of 44 rivers are yet to be prepared though envisaged in the State Water Policy. Non-availability of Master Plans for the major rivers of the State implies scope for inclusion of flood control works on ad hoc basis.

GoK stated (March 2020) that micro watershed plans containing details of traditional water bodies such as ponds, lakes, streams and springs were prepared at Grama and Block Panchayat level under 'Haritha Kerala Mission'. However, the fact remains that a State level Master Plan for water resources development and management as envisaged in the SWP is yet to be prepared. During the Exit conference (February 2021), Additional Chief Secretary, Water Resources Department stated that a draft bill had been finalised for constitution of River Basin Conservation and Management Authority. The Department also informed (April 2021) that when the model code of conduct is lifted, the bill is expected to be passed as an ordinance. As per the State Water Policy 2008,

8 Out of 44 major rivers in Kerala
9 Gayatripuzha and Thoothapuzha

preparation of State level Master Plan for water resources development and management is to be a combined effort of various stakeholder departments and the formulation of the same is progressing under the authority of Town and Country Planning Department. With respect to the preparation of master plans for major rivers in the State, priority will be given to those rivers that are prone to flood and passing through densely populated areas viz. Periyar, Chalakkudy, Pamba, Meenachil, Muvattupuzha, Karamana, Bharathapuzha and Chaliyar rivers.

Recommendation 2.2 Government may ensure compliance with the provisions of the Kerala State Water Policy such as formulation of a State level Master Plan for water resources development and management, formulation of Master Plans for the major rivers besides constituting a State Level Authority to coordinate all water related activities at the river basin level.

[Audit paragraph 2.2 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

3. When the Committee enquired about the audit observation regarding non preparation of State Level Master Plan for Water Resources Development and Management, the Chief Engineer, Irrigation and Administration explained that the River Basin Conservation and Management Authority (RBCMA) was in the process of being established

to carry out a thorough study on the management and planning of water resources at the State level. A drafting committee had been set up in connection with that initiative and a proposal for its formation had been submitted to the Government for approval. The Committee noted that the Government's reply indicated that preparations were already underway for creating master plans for rivers, with a focus on gathering data for all major rivers in the State within a specified time frame. The Committee sought an update on the progress of the project initiated in 2022. The Chief Engineer, Irrigation and Administration informed that a comprehensive planning effort for the whole State had not been incorporated into the master plan. Furthermore, he mentioned that an in-depth study of the Pamba river basin is currently in progress and is anticipated to be completed by December 2024. Additionally, the Chief Engineer stated that the aim of the proposed River Basin Conservation and Management Authority (RBCMA) was to conduct a thorough examination of all rivers within the State and to ensure the co-ordination of relevant activities. The Committee noted that although a plan had been developed, significant delays had occurred in its implementation. The Chief Engineer, Irrigation Design and Research Board and Irrigation & Inter-State Water, Thiruvananthapuram, further clarified that the RBCMA had not yet become operational. As the process involved a combined effort of various stakeholders, concerns were raised by various stakeholder Departments during the preliminary drafting of the Act. It was suggested in a meeting led by the Chief

Secretary that, the draft be circulated to the relevant Departments to gather their suggestions prior to finalization. While feedback from the Revenue, Disaster Management Department had been received, feedback from other Departments was awaited. The procedures to finalize the Act was currently underway and would be concluded in due course.

4. The Committee sought information regarding the proposed functions of the River Basin Conservation and Management Authority (RBCMA). The Chief Engineer, Irrigation Design and Research Board, Irrigation and Inter-State Water Division, Thiruvananthapuram, clarified that, in accordance with the State Water Policy, any initiatives concerning river management should be based on comprehensive evaluations that included factors such as the river's catchment area, the volume of water flow, its utilization, and the land use adjacent to the rivers. He emphasized that the formulation and implementation of such a plan necessitated the co-operation and data collection from various Departments, including Revenue, Agriculture, Irrigation, Local Self-Government, Power, Forest, and the Pollution Control Board. He supplemented that the most important function of the authority would be to prepare a clear river basin plan for each river and co-ordinate the activities related to that with other Departments and execute them in a timely manner. Furthermore, it was noted that a draft of the State Water Policy was submitted to the Government in April 2023. The Special Secretary, Water Resources Department mentioned that the draft of the

State Water Policy had recently been received by the Administrative Department. It was decided at the minister level that no amendments would be made to the policy, and final approval would be granted by the Drafting Committee promptly upon the assumption of Office of the new Secretary. It was also stated by Special Secretary that the draft policy after approval by drafting Committee has been submitted for cabinet approval. In response to a query from the Committee regarding the establishment of the RBCMA, an official from the Water Resources Department indicated that a draft bill was being prepared as legislation was necessary for the establishment of the RBCMA. The Principal Secretary, Revenue and Disaster Management Department confirmed that they had already submitted relevant data regarding that process.

5. During the Committee's enquiry regarding the timely submission of data, an official from the Water Resources Department highlighted that delays occurred due to the need for feedbacks from various Departments, including the Agriculture Department, as well as repeated requests for comments from stakeholders. Additionally, the Revenue Department raised several new concerns. As a result, it was determined that legislation should be made to address those issues comprehensively. The Committee expressed its view that it would be more effective to establish a single authority to oversee all the major rivers, rather than creating separate authorities for each river. The Committee expressed its concerns regarding the lethargy of the Department in addressing those matters, particularly the delays in

finalizing the State Level Master Plan for water resources and development, as well as the formation of the State-level River Basin Conservation and Management Authority (RBCMA). The Committee directed that those tasks be prioritized and completed at the earliest.

Conclusion/Recommendation

6. The Committee expresses its concern over the lethargy of the Department in addressing matters such as delay in finalising the State level Master Plan for water resources development and the formation of the State-Level River Basin Conservation and Management Authority. The Committee directs that the formulation of a State-Level Master Plan for Water Resources development and framing of master plans for all major rivers should be ensured by the Government in a timely manner.

7. The Committee opines that undue delay in setting up of RBCMA is not acceptable and calls for immediate steps to constitute River Basin Conservation and Management Authority within a specific time frame.

2.3. Non-enactment of legislation to identify and demarcate Flood Plains in the State

Flood plain zoning is a concept central to flood plain management. This concept recognises the fact that the flood plain of a river is essentially its domain and any intrusion into or developmental activity therein must recognise the river's 'right of way'[10]. Flood plain zoning measures aim at demarcating zones or areas likely to be affected by floods of different

10 Source: Planning Commission, GoI, Report of Working Group on Flood Management and regionspecific issues for XII Plan (2011).

magnitudes or frequencies and probability levels, and specify the types of permissible developments in these zones, so that whenever floods actually occur, the damage can be minimized, if not avoided. A model draft bill for flood plain zoning legislation was circulated by the Union Government in 1975 to all the States. The proposed legislation envisaged creation of a Flood Zoning Authority, survey of flood plains and prohibition or restriction in the use of these lands. The National Disaster Management Authority's (NDMA) guideline on 'management of floods' also has a section on enforcement and regulation related to flood plain zoning.

The State of Kerala has not enacted flood plain zoning legislation and the flood plains of the State have not been identified and demarcated. Had the exercise of identification and demarcation of the flood plains been undertaken, the same could have been used by GoK in their activities on flood control.

The Department of Water Resources replied (November 2020) that the State of Kerala had informed (2013) the Ministry of Water Resources and Ganga Rejuvenation about the practical difficulties and limitations of enacting the flood plain zoning legislation in Kerala. It added that the topography of Kerala was unique when compared with the States that had implemented the legislation.

However, Audit observes that while there may be challenges in implementing such a legislation as envisaged for flood plain zoning, it should not become an absolute deterrent to even initiate a process of

identification of the flood plain zones for the 44 major rivers as well as the level of urbanisation and development activities. As per the NDMA Guidelines also, flood plain zoning is necessary to minimise damage in the case of floods by rivers. According to Kerala State Disaster Management Plan, 2016, flood plains are flood prone and hazardous if developmental activities in them exceed an acceptable level. It further states that reclamation and settlement in flood plain areas is a major cause of flood damage in the State. Further, during the course of audit, 913 encroachments of water bodies were noticed in the selected districts as detailed in Appendix III(2). Legislation to identify and demarcate flood plain zones of the State would enable the Government to take proactive measures in controlling potential encroachment activities in the flood plains.

The Department replied (April 2021) that in India, only three States namely Manipur, Rajasthan and Uttarakhand had enacted the legislation as of December 2016. Kerala had never been considered as a major flood prone State till the flood of 2018 unlike the States located in Indo Gangetic plain. The States located on the banks of Ganges, Yamuna and Brahmaputra basins are yet to enact the Flood Plain Zoning Bill. Flood plain zoning needs institutional support and interdepartmental coordination. Though Kerala has an undulating topography and a high population density, Government recognises it is a vital tool in preventing flood. Feasibility study on enacting the Flood Plain Zoning Bill in the State would be conducted when the new Government comes to power.

Audit noticed that the need to prevent encroachments along rivers and flood plains was again emphasised in the draft River Regulation Zone notification, 2016, under the Environment (Protection) Act, 1986 which was circulated to the States by the Ministry of Environment, Forests, and Climate change (MoEFCC). The notification proposes to declare river stretches and flood plain zones as river conservation zones and to regulate or prohibit developmental activities in these zones. Further, though the Coastal Regulation Zone Notification of January 2011 (as amended in 2019) envisages that coastal land from High Tide Line upto 50 m[11] on the landward side along rivers subject to tidal influence fall under the coastal regulation zone and would be regulated as per the provisions of the Act, this would not suffice to check encroachments, as flood plains of only some rivers/stretches of rivers in some districts are covered under the CR Zones.

Flood plains and river beds are some of the natural features that allow absorption of heavy rainfall or a river's overflow and facilitate mitigation of adverse effects, hence permitting uncontrolled constructions and encroachments, particularly in an era of climate change could be extremely short-sighted. Recognising the river's right to expand and contract over seasons is vital. Notwithstanding the practical difficulties in implementing flood plain zoning legislation/ regulation in a densely populated State like Kerala, the Government needs to ensure through active stakeholder engagement that this gap in the regulatory

11 100 m upto 17 January 2019

framework is not allowed to persist.

Recommendation 2.3: Government of Kerala may initiate action for a legislation/regulation on flood plain zoning, as well as constitute an Authority to identify and demarcate flood plain zones of the State and to prohibit or restrict the use of these lands.

[Audit paragraph 2.3 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

8. While considering the audit observation related to the non enactment of legislation to identify and demarcate Flood Plains in the State, the Chief Engineer, Irrigation and Administration, provided insights into the challenges associated with demarcating flood plain zones in Bharatapuzha, Periyar, and Pamba river basins. It was noted that those areas were characterized by high population density and the presence of infrastructure, including hospitals, industrial establishments, and agricultural lands. Consequently, it was essential to adopt a pragmatic approach that involved co-operation and consensus among all stakeholders, taking into account the dynamic nature of river flow when planning for flood plain management. Furthermore, the Committee highlighted that the overflow of rivers could be attributed to inadequate sand removal in a scientific manner, as well as the presence of vegetation growth within the river channels. Similar circumstances had

been observed in the case of the Bharathapuzha River, too.

9. The Committee expressed concerns regarding the lack of measures being implemented for the desiltation of rivers. Specifically, it was noted that no action had been taken for the removal of accumulated waste from the rivers, and for the regulated extraction of sand. The Principal Secretary, Revenue and Disaster Management Department, indicated that, following the Order of the National Green Tribunal (NGT), the Union Ministry of Forests and Environment had released guidelines addressing river desilting, which were supported by existing regulations in the State. Additionally, the Revenue Department had conducted a comprehensive study by evaluating the quantity of sand present in the rivers and the feasible quantities available for mining, and had implemented relevant measures accordingly. The Committee was of the view that explanation provided by the Chief Engineer concerning flood plain zoning was impractical and sought clarification on the status of the decision made on 14th March, 2024, regarding the convening of a technical conclave. The Member Secretary, KSDMA informed the Committee that current construction activities within the designated river basins, classified as flood plains, were legally prohibited. A clear definition of the term 'river basin' necessitated consideration of specific technical and administrative factors. Consequently, the Permanent Expert Technical Committee had resolved to engage in stakeholder consultations on that issue. Subsequent discussions involving the IDRB and other institutions had taken place, although a precise definition of

the term remained elusive among experts. An example highlighted was the Maharashtra Government, which successfully defined 'river basin', yet did not encompass the concept of 'river Poramboke,' leading to complications for certain construction projects and the relocation of residents. In the case of Chengannur Municipality, river basins and flood plains had been marked as part of the development of Risk Informed Master Plans at the local level. If such a notification was issued for the area, it could significantly impact construction activities across six wards approximately. Hence, all socio-economic factors would be considered while addressing those implications.

10. To the further queries of the Committee, the Member Secretary, KSDMA requested that the order issued by the National Green Tribunal (NGT) in that matter may be taken into consideration by the Committee. He noted that in earlier period permission had been granted for the expedited removal of materials accumulated in rivers during flood events. However, the NGT has revised its guidelines when the Pamba River issue arose, stipulating that no actions could be undertaken even without prior clearance from the State Environment Impact Assessment Authority (SEIAA) for disaster management.

11. To a query of the committee regarding the non – conducting of a detailed technical conclave decided to be held on 14.03.2023, the Chief Engineer, Irrigation Design and Research Board & Irrigation & Inter State Water, Thiruvananthapuram clarified that discussions had not yet been

conducted specifically related to the demarcation of flood-prone areas. A comprehensive plan was currently underway for the Pamba River Basin, focusing on future flood response measures. The conclave was held in two phases, including participation from local representatives, and the relevant details would be submitted to the Committee. The Chief Engineer also mentioned that different opinions among experts concerning the definition of "flood" should be addressed. Various Departments were engaged in discussions regarding potential actions to be taken in the event of peak flow occurrences.

12. The Principal Accountant General disagreed with the view that flood plain zoning was not feasible. It was noted that other states had successfully implemented such measures. Implementing flood plain zoning was considered a globally accepted practice, and it would be unjust to regard it as impractical at the Governmental or disaster management level. Therefore, he suggested that the Committee may take appropriate decision on that matter. The Principal Secretary, Revenue and Disaster Management Department updated that the Central Water Commission (CWC) had initiated studies pertaining to flood plain zoning, although comprehensive details were still forthcoming and the Department was currently awaiting the CWC's report.

13. The Principal Accountant General brought to the attention of the Committee that a proper policy had not been formulated in the State and the establishment of RBCMA had not yet been completed. He

further stated that the delay in that regard would be treated seriously and stressed the need for urgent corrective measures. The Committee opined that the undue delay would not be tolerated and a specific time frame would be decided in that regard. The Committee enquired whether it could be completed before 31st December, 2024. The Chief Engineer, Irrigation & Administration replied that the Irrigation Department alone could not accomplish that goal as co-operation among various stakeholder Departments would be essential for its successful completion.

14. The Committee suggested that in the interest of efficiency, the Department should explore utilizing systems from alternative sources or consider outsourcing to private agencies, rather than relying solely on existing Departmental resources. It was proposed that survey work related to flood plain zoning be delegated to engineering colleges located near the rivers. Through such an arrangement, the colleges could receive a predetermined fee for their services, thereby streamlining the process. The Principal Secretary provided an update on the mapping efforts undertaken so far, indicating that preventive measures had also been implemented and communicated to the local bodies concerned. Furthermore, she emphasized the necessity for appropriate legislative action to facilitate the zoning of flood plains.

15. The Member Secretary, KSDMA clarified that the audit observation centered on the zoning of flood plains and the creation of a flood

hazard map. When flood plain zoning was conducted by the State many years ago, there remained a significant concern regarding constructions in proximity to river basins. He emphasized that relevant details regarding the matter would be furnished within one month following consultations with the Departments concerned. The Committee also opined that the said process should be expedited by incorporating the input of local representatives and fostering co-ordination with engineering colleges.

16. In continuation of the discussion, the Member Secretary, KSDMA informed that sedimentation resulting from the major flood event in 1924 had impacted regions such as Kuttanad. As temperature increased, river valleys shrank and riverbanks were formed. Residents living near the banks of Periyar river were to bear the brunt of the effects of flood for several years. Areas designated as river purambokes were projected to experience flooding approximately every ten years. Upon excavation in those locations, deposits of rocks and sand were found with muddy sand at deeper levels, contributing to the shrinking of rivers. To address that issue, he proposed the implementation of a strategy known as "Room for Rivers." That method involves the removal of barriers designed to prevent water from entering the banks, thereby allowing for additional space for water to flow. He concluded that the said approach could be seriously considered while moving forward.

Conclusion/Recommendation

17. The Committee directs to submit a report on the action taken by the Department to ensure the availability of large scale flood hazard maps for the identification of the risk prone areas and to prioritise response efforts.

2.4. Flood Hazard Map not conforming to criteria

Flood Hazard Mapping is a vital component to facilitate the identification of areas at risk of flooding and also helps to prioritise mitigation and response efforts[12].

An Expert Committee constituted by GoI[13] for scientific assessment of flood prone areas in India defined (June 2013) flood prone areas as such areas affected by floods which have a return period of 10 years viz. probability of its recurrence and emphasised that the return period of flood would be one of the important criteria for classification of flood prone areas. Flood prone areas were to be initially categorised as Severe, Moderate and Normal. Methodology for identifying these areas as such were also detailed by the Expert Committee. The Expert Committee recommended that each State should set up a Regional Committee which, among other things, would be responsible for delineating flood prone areas of the State based on methodology finalised by it. The State was bound to follow the procedures laid down by the Expert Committee. In line with GoI recommendations, GoK constituted[14] (October 2014) a Regional Committee to identify,

12 Source: Flood Hazard Atlas of Odisha prepared by National Remote Sensing Centre, GoI
13 Ministry of Water Resources, Central Water Commission
14 Additional Chief Secretary, Water Resources Department as Chairman, Chief Engineer,

demarcate and classify the flood prone areas in Kerala.

GoK formulated a Kerala State Disaster Management Plan approved by the SEC and KSDMA (September 2016) which was intended to be an ever evolving document formulated under the Disaster Management Act 2005. Audit noticed that the map adopted by GoK and incorporated in the Kerala State Disaster Management Plan 2016 was prepared (2010) by the National Centre for Earth Science Studies (NCESS)[15] in 1:50,000 scale using satellite images. Though Central Water Commission (CWC) in June 2013 had fixed the return period of flood as the criteria for identifying flood prone areas, GoK continues to rely upon a flood prone area map prepared in 2010 which does not adhere to the criteria fixed by CWC for earmarking an area as flood prone.

The inadequacy of the maps adopted in the DM Plan was evident from the reply of NCESS to Audit (July 2019) that large scale maps would be required for application at the local level. The need for integrating field mapping, high resolution satellite images and Digital Elevation Models for generation of database for local level application was also emphasised by NCESS.

Thus, flood susceptibility map of NCESS as adopted by GoK in its Disaster Management Plan needs to be revisited in order to make it useful for local level applicability.

Audit observed that the Regional Committee[16] constituted (October

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CWC Coimbatore as Member Secretary, Secretary, KSDMA as member and two other members

15 NCESS – formerly known as Centre for Earth Science Studies

16 Based on the recommendations of Expert Committee for Scientific Assessment of Flood Prone Areas in India, Government of Kerala constituted (October 2014) a Regional

2014) to identify, demarcate and classify the flood prone areas in Kerala by July 2015 met only twice during 2014-19 and could not achieve its stated objective.

GoK in its response stated that

- the flood susceptibility map was prepared by the State in 2010 when the Expert Committee's recommended methodology was not available. It is not meant to be a substitute for the large scale Flood Hazard map required to be prepared (in accordance with the methodology prescribed by the Expert Committee) and provided by the Ministry of Water Resources, National Remote Sensing Centre, Survey of India and Central Water Commission as notified in the Disaster Management Plan of 2016 and the National Disaster Management Guidelines-Management of Floods 2008, which when obtained, would be incorporated in the State Disaster Management Plan.
- The Department said that CWC informed (May 2020) that there was not much progress in the matter of large-scale flood mapping due to non-availability of high-resolution digital elevation models for the States. Thus, the delay in identification, demarcation and classification of flood prone areas cannot be attributed to the State Government.
- In the Exit Conference (18 January 2021) Member Secretary, KSDMA stated that the NCESS map adopted in the State DM Plan

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Committee with Additional Chief Secretary, Water Resources Department as Chairman to identify, demarcate and classify the flood prone areas in Kerala.

2016 had an accuracy of 70 per cent which was sufficient for all planning purposes.

The reply of the Government confirms the audit observation that the State is yet to have a large-scale flood hazard map satisfying the criteria, even though the flood hazard map is a vital component for identification of risk prone areas and to prioritise response efforts. Though seven years have elapsed since the methodology was prescribed for preparation of flood prone map, the State is still dependent on the 2010 map.

Audit observed that United Nations Development Programme in its Post Disaster Needs Assessment document[17] (released after the Kerala floods of 2018) referring to the available map notes that the same has been prepared at a scale of 1:50,000 while indicating that this has resulted in awareness among the citizens about hazards and environmental conservation, these maps should ideally be prepared at a scale of 1:10,000 or 1:5000 if they are to be useful for planning and policy making. Accordingly, the contention raised in the Exit Conference that this map is sufficient for planning is not acceptable because the map does not meet the criteria set by CWC and also since NCESS, which created this map had informed Audit that the map is insufficient.

Recommendation 2.4: Government of Kerala may take steps to ensure availability of large scale flood hazard maps conforming to CWC criteria which would facilitate planning, policy making and prioritisation of flood

17 Commissioned by the Kerala Government, the Kerala PDNA was undertaken jointly by experts from the line Ministries and the United Nations.

mitigation activities by identifying flood risk areas.

[Audit paragraph 2.4 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

18. While discussing the above para, the Member Secretary, KSDMA provided an overview regarding the preparation of the Flood Hazard Map for Kerala, which is being developed by the National Centre for Earth Science Studies. Following the enactment of the Disaster Management Act of 2005, agencies under the Central Government were assigned the responsibility of identifying vulnerable areas. Due to the delay occured in that process, a decision was made to utilize the map developed by NCESS, and based on that map restrictions were being imposed. He added that in the meantime, the verdict of the WP(c)33405/18 filed by the CWC was issued by the Hon'ble High Court of Kerala in 2022. The judgment of the case stated that "Perusal of the same shows that several factors are being considered for the scientific assessment of flood prone areas in the State and Court cannot fix any outer limit for the completion of this work. Almost all the reliefs have been addressed by the respondents. In view of the above, the writ petition is disposed of directing the respondents to take all possible remedial measures and regularly monitor the same without any failure." In the mean time KSDMA in co-ordination with UNEP had developed a

flood hazard probability map for the entire State, which was published in the Orange Book. That map categorizes flood risks across a range of frequencies from 10 to 500 years and identifies critical infrastructure such as schools and hospitals within those risk zones. That information has been disseminated to the Local Self Government Institutions, with the understanding that its validity is contingent upon the publication of the map by the CWC. Furthermore, the Hon'ble High Court of Kerala had accepted the CWC's request for an extension of time period to complete the preparation of the map. Ultimately, Central Water Commission bears the legal responsibility for creating large-scale, high-resolution flood maps, as mandated by the National Disaster Management Authority under the Disaster Management Act of 2005.

Conclusion/Recommendation

19. No comments

Capacity Building in Disaster Management

2.5. Implementation of Civil Defence in the State

The Disaster Management Act envisages requisite institutional mechanisms to promote general education, awareness and community training in regard to forms of disasters to which different parts of the State are vulnerable and the measures that may be taken by such community to prevent the disaster, mitigate and respond to such disaster. In order to create a mechanism for efficient and effective response to any natural or manmade emergency, a sizable trained volunteer force of emergency responders at the grassroots level needs to be made

available as standby in all vulnerable urban/rural areas[18]. Accordingly, amendment was enacted (2009) to the definition of "civil defence" contained in the Civil Defence Act, 1968 so as to bring within its scope the measures which may be taken for the purpose of disaster management during, at, before, or after any disaster. Since the community was invariably the first responder to any disaster, adequate awareness and preparedness of the community to respond to any such emergency/disaster would be very crucial in mitigating the damage and suffering.

In Kerala, the post of Director of Fire Force was redesignated (October 1980) as the Commandant General (Home Guards, Civil Defence and Fire Services). However, Civil Defence was officially formed in the State under the Fire and Rescue Services Department only on 30 August 2019. Consequently, the implementation of three schemes launched by GoI during 2009-2016 to strengthen civil defence in the State viz., 'Revamping of Civil Defence, 'Mainstreaming Civil Defence in Disaster Risk Reduction' and the 'Aapda Mitra' scheme suffered setbacks. An amount of ₹4.43 crore was released by GoI during the period towards implementation of these schemes, which could not also be effectively utilised. Audit noticed that due to non-formation of Civil Defence in the State, little headway was made in implementing these schemes meant to ensure the availability of an active volunteer-based emergency force for disaster mitigation. The following three paragraphs highlight the

18 Suggestions of K. M. Singh (Member NDMA) Committee to integrate Civil Defence in Disaster Management framework, endorsed by Home Minister's Civil Defence Advisory Committee in April 2008

issues observed by Audit.

[Audit paragraph 2.5 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

20. While discussing the above para, the Committee enquired about the audit observation regarding the utilisation of the building constructed in 2014 envisaged to function as a State Level Residential Training Institute as a camping place for NDRF. The Director General, Kerala Fire & Rescue Services informed that Civil Defence System was formed under the Kerala Fire and Rescue Services in 2019. Even though a Civil Defence Training Academy was set up in Thrissur, the building was currently being used as a camping station by the NDRF. Even though land was allotted for NDRF in Ernakulam, relocation was not possible due to the denial of permission from Coastal Zone Management Authority. He added that the location of NDRF camp in the central region facilitates immediate response during natural calamities. He further stated that a request had been submitted to the Revenue Department for the allocation of four acres out of the eight acres of land in the vicinity to establish a Civil Defence Academy. At present, there was no specific Training Institute for Civil Defence, and Civil Defence Training was provided by using the facilities of Fire Service Academy and the 127 fire stations throughout the State.

Conclusion/Recommendation

21. No comments

2.5.1 Unfruitful expenditure of ₹1.54 crore on construction of Civil Defence Training Institute

Figure 2.1: Civil Defence Training Institute Building 29 October 2019, CDTI, Viyyur, Thrissur District Photo taken by Audit party, attested by Director, Fire and Rescue Services Academy

Audit observed that under the scheme 'Revamping of Civil Defence' launched by GoI in July 2009, ₹154.20 lakh out of ₹195 lakh received from GoI was expended on construction of a Civil Defence Training Institute (CDTI) at Viyyur in Thrissur district. Joint field verification (October 2019) revealed that though the building, completed in 2014, was envisaged to function as a State level residential training institute for civil defence under the Fire and Rescue Services Department (F&RSD), it was being utilised as a camping place for members of the National Disaster Response Force (NDRF), with the classrooms and dormitory converted as barracks. Audit observed that the building which was in possession of Revenue Department till April 2018, was handed over to F&RSD on the pre-condition that the NDRF battalion was to be accommodated in the building until a new own building was identified. Joint verification (October 2019) revealed that possession of only a small room had in fact been transferred to the Director of CDTI, which was used for office functioning, with the rest of the building continuing to be occupied by NDRF. The residential training

centre to impart training to civil defence volunteers has not become functional despite passage of over five years. Had the State rolled out Civil Defence, selected the volunteers and trained them in a timely manner,the CDTI building could have catered to the envisaged objective. Audit had previously pointed out[19] the non-functioning of CDTI due to delay in creation of posts and purchase of equipment, to which GoK replied (November 2016) that the responsibility to activate CDTI has been entrusted to KSDMA. The reply offered by GoK in November 2020 was that the temporary pre-positioning of NDRF team in the building facilitated judicious utilisation of an otherwise idling building. It was also stated that there was adequate facility in the Fire and Rescue Services Academy to provide captive training to Civil Defence Volunteers and in-service men. The reply is contrary to facts as it was the responsibility of KSDMA to activate CDTI building so as to cater to the dedicated purpose of a full-time residential training institute for civil defence, which remains unrealised. Further, DG, F&RS stated (December, 2020) that as a variety of training schedules[20] were being conducted in Fire and Rescue Services Academy, it was essential to allot maximum space for the residential training of civil defence volunteers at CDTI. On pointing this out in Exit Conference (January, 2021), GoK stated that though allocations were made for construction of CDTI and DG, F&RS designated as Director General (Civil Defence), Civil Defence was not notified in the State until 2019. For this reason, even if a building was

19 Paragraph 4.4.6.1 of the Audit Report of Comptroller and Auditor General of India for the year ended March 2016, currently under consideration of PAC.

20 Station officer course, Driver Mechanic course, Fireman course etc

constructed there, no training would have happened and the scenario of State's flood response would not have changed. The reply reveals the low priority given to the formation of Civil Defence and for equipping the volunteers as emergency responders in crisis situations. Despite designating Director of Fire Force as the Head of Civil Defence as early as in October 1980, the State was left without any civil defence volunteers for the past 38 years.

During the Exit Conference, Audit was informed that, now that a separate piece of land has been allotted to NDRF for constructing their own building and Civil Defence has been formed, NDRF would move out soon. In view of the idling of existing infrastructure provided for training in the past years and construction of new building not having commenced yet, the possibility of NDRF moving out and the entire building of CDTI being utilised for Civil Defence related trainings in the near future remains doubtful.

2.5.2 Mainstreaming Civil Defence in Disaster Risk Reduction

Government of India scheme 'Mainstreaming Civil Defence in Disaster Risk Reduction' for strengthening the Civil Defence setup in the Most Vulnerable Districts/ Multi Hazard Districts envisaged creating a response system based on minimum permanent staff backed by skilled volunteers. Six[21] districts in Kerala were classified (2014) as 'Most Vulnerable'. Ministry of Home Affairs released (November 2014) ₹225.52 lakh as first instalment of grant-in-aid to the State for the financial year 2014-15. This included ₹198.52 lakh for the six most

21 Ernakulam, Kannur, Kottayam, Kozhikode, Thiruvananthapuram and Wayanad

vulnerable districts and ₹27 lakh to the CDTI envisaged under the scheme 'Revamping of Civil Defence'. Audit observed that the entire ₹225.52 lakh received in November 2014 was retained by the Finance Department until March 2017, when it was provided in the budget as Supplementary demand for grants, as proposed by the Revenue Department. As the Director General of Civil Defence did not receive the money, the scheme could not be implemented and the amount was resumed by GoK in June 2017 without any further disbursement. Thus, GoI assistance of ₹225.52 lakh for strengthening of Civil Defence set up in the State could not be utilised for the envisaged purpose. GoK replied that a request has been made (November 2020) to Home Department to revalidate the amount for implementation of the scheme by F&RSD.

[Audit paragraphs 2.5.1 and 2.5.2 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraphs are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

22. During the Committee's enquiry regarding the audit observation concerning the unfruitful expenditure of ₹1.54 crore on the construction of the Civil Defence Training Institute, the Director General of Fire and Rescue Services clarified that the building is currently utilized by the National Disaster Response Force (NDRF). In response to the Committee's query about Civil Defence recruitment, he informed that

over ten thousand volunteers were there from various sectors of society, and Government officials were also encouraged to participate. To facilitate that, the Government had issued an order allowing special casual leave for Government employees engaged in Civil Defence activities. Notably, there is no age restriction for joining, as these volunteers do not receive remuneration. The Committee highlighted that the audit observation pertained to the construction of the building intended for use as a Civil Defence Training Institute, which is presently occupied by the NDRF team and urged that the said issue would be addressed promptly. The Director General further explained that the building currently serves as a training center and camp for the NDRF, emphasizing its strategic location that allows for efficient movement to various regions in the event of natural disasters. The Member Secretary, Kerala State Disaster Management Authority, informed that at present five acres of land were allotted to the NDRF in 2016. However, the NDRF requested marshy land with water frontage. Subsequently, land located at Irumbanam near the Indian Oil Corporation was allocated and is currently pending clearance from the Kerala Coastal Zone Management Authority (KCZMA). Construction of the building is anticipated to commence in 2025.

23. In response to the query of the Committee about the audit observation regarding the retaining of ₹225.52 lakh released by the Central Government as the first instalment of grant- in-aid to the State for the financial year 2014-15, the Director General, Kerala Fire and

Rescue Services informed that the Civil Defence system had been established in the State in 2019.

Conclusion/Recommendation

24. No comments

2.5.3. Slow pace of implementation of Aapda Mitra Scheme

National Disaster Management Authority (NDMA) approved 'Aapda Mitra', a 100 per cent Centrally Sponsored Scheme, with focus on training 6000 community volunteers in disaster response in the 30 most flood prone districts (200 volunteers per district) in India. This was to bestow them with skills needed to respond to the immediate needs of their community and undertake basic relief and rescue tasks during emergency situations such as floods, flash floods and urban flooding. In Kerala, Kottayam district was selected for implementation of the scheme. Consequent upon signing (November 2016) of MOU of two-year validity with KSDMA, NDMA released ₹22.70 lakh[22] to GoK in February 2017.

Audit observed that while more than half of the beneficiary States[23] had completed the selection of volunteers and were about to commence training for volunteers in 2017 itself, KSDMA forwarded the list of selected volunteers from Kottayam district to NDMA only in February 2018. Verification of records at F&RSD and KSDMA showed that though the allotted funds were resumed in February 2018, GoK released the

22 50 per cent of the sanctioned amount.

23 Andhra Pradesh, Delhi, Gujarat, Himachal Pradesh, Karnataka, Manipur, Meghalaya, Nagaland, Punjab, Tamil Nadu, Tripura, Bihar, Uttarakhand and West Bengal as per the information provided by NDMA in March 2021

amount subsequently to KSDMA in June 2018 and KSDMA arranged training to 200 enlisted volunteers from Kottayam from October 2018 to March 2019. Thus, the services of the envisaged trained team of community volunteers were not available during the floods of August 2018.

Audit further observed that the emergency responder kits[24] to the trained volunteers were distributed by KSDMA only in December 2019, one year after the completion of training of the first batch of volunteers. Purchase of emergency stockpile[25] was still under process (May 2020).

The Department of Revenue and Disaster Management replied (November 2020) that

- While the project was launched in November 2016, the modalities for implementation were briefed in the National Technical Committee meeting on 01 April 2017 following which the first meeting of the State Project Steering Committee was held on 31 August 2017 in which public notice for the scheme was handed over to DDMA Kottayam for circulation. The scheme was formally inaugurated on 13 October 2017.
- Owing to adverse ways and means position, the first instalment of ₹22.70 lakh allotted to KSDMA vide GO dated 14 March 2018 was not released and after allotment in 2018-19, the amount was

24 Kits comprising Life Jacket, Solar Torch, Safety gloves, Nylon rope, Pocket knife, First Aid Kit, Rain coat, Water bottle etc.

25 Stockpile consisting of Personal Floatation device, Torch, Safety Gloves, Rope, Lifebuoy, Oars, Paddles, Anchors, Bailer, OB Motor, Fire Extinguisher, Emergency Spotlight, Stretcher, Tool Kit, Walkie-talkie, first aid kits, GPS sets etc.

finally credited to KSDMA account in June 2018, after which alone activities such as printing of training modules, training of volunteers etc. could be taken up.

- Fire and Rescue Services Academy was approved as the training Academy by NDMA on 08 June 2018.
- The catastrophic floods of August 2018 rendered the entire operational machinery out of gear and KSDMA being in the vanguard of the Disaster Management activities could not provide attention to other matters.
- The second instalment of ₹22.70 lakh was allotted vide GO dated 21 December 2019. Despite the delay in receipt of funds, KSDMA managed to supply the emergency responder kits in December 2019 itself.
- GeM portal through which emergency responder kits were purchased had many glitches and required frequent communication with GeM portal managers for rectification. Samples of each item had to be purchased first to get assurance of quality and this took time.
- KSDMA has organised various programmes to ensure continued participation of volunteers in the mission 'towards safe state'. Exposure and orientation programme (29 January 2019), training on Civil Defence (10 December 2019), annual refresher training for volunteers (09 to 12 July 2019), meeting with Unit Coordinators (13 November 2019) were conducted.

- The State is considered by NDMA as a model State in the implementation of Aapda Mitra scheme. NDMA decided to conduct the national review meeting in Kerala in 2020 to demonstrate the achievements of Aapda Mitra in Kottayam district.
- Further, Government of India has extended (July 2020) the project till 31 December 2020 as most States could not complete the programme owing to local implementation difficulties.
- Training by Fire and Rescue Services Academy commenced on 22 October 2018 after the floods of 2018 (meant for 200 volunteers in batches of 25) on specific dates. Many volunteers dropped out citing personal and livelihood reasons, captive nature and length of training etc. Aapda Mitra being a voluntary capacity building programme, there is no legal provision to demand work from volunteers who render work voluntarily based on request.
- The programme was successful in Kerala as owing to the pragmatic approach of NDMA, KSDMA and the DDMA, they were able to impart a spirit of voluntarism in the participants.

During the Exit Conference, it was added that the scheme deadline has been extended to March 2021.

Audit noticed that subsequent to signing of MoU of Aapda Mitra Scheme in November 2016, procedural delay at various individual stages[26]

26 First meeting of the State Project Steering Committee took place five months after the National Technical Committee meeting, hence request for list of volunteers was sent only in August 2017 by KSDMA, list forwarded by DDMA Kottayam received by KSDMA in

resulted in distribution of emergency responder kits in December 2019, one year after completion (October 2018) of training of the first batch of Aapda Mitra volunteers. Thus, the disaster response skills acquired by the volunteers were yet to be supplemented with vital equipment for basic relief and rescue and coordinated under the Aapda Mitra scheme for the benefit of the local community, despite another severe flood having affected the State in August 2019. The justification of Government that the extension of the project (July 2020) till 31 December 2020 (and subsequently till 31 March 2021) by GoI due to the fact that most States could not complete the programme owing to local implementation difficulties is not acceptable as a reason for justifying the slow pace in Kerala which has a higher degree of disaster risks as compared to the rest of the country (Paragraph 1.2 of Kerala State Disaster Management Plan 2016) and more so when there was only one selected district (Kottayam) as part of the programme. Further, it was seen that the list forwarded to KSDMA was taken directly from the Community Rescue Volunteer Scheme list in Kottayam by the DDMA. Being readily available, this could have been forwarded much earlier than February 2018 to NDMA, had the level of preparedness been higher.

Though it was stated that the F&RS Academy was approved by NDMA as the training Academy in June 2018 only, as pointed out in Paragraph 2.5.1 of this report, the State had a Civil Defence Training Institute right

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November 2017 was forwarded to NDMA only in February 2018, release of funds by GoK in June 2018 and of second instalment by December 2019.

from 2014, which if utilised as a dedicated training institute, could have catered to the training needs of Aapda Mitra too. Further, DG (F&RS), had earlier requested (November 2017) Revenue and Disaster Management Department to handover the CDTI building and premises urgently for conducting trainings of Aapda Mitra/ Community Rescue Volunteer Scheme.

Though the reply mentioned (November 2020) that the State has been considered by NDMA as a model State in the implementation of Aapda Mitra scheme and that NDMA even decided to conduct the national review meeting in Kerala in 2020 to demonstrate the achievements in Kottayam district, Audit noted that the document forwarded in support of the 'national review' meeting in fact pertained to a 'regional assessment' workshop and the contention of Kerala being a model State in Aapda Mitra was not supported by documents.

Recommendation 2.5: The State may initiate action to operationalise the Civil Defence Training Institute for the fulfilment of the intended objective of training and equipping sufficient number of Civil Defence volunteers. Civil Defence needs to be strengthened in the State through ensuring a) adequacy of communication facilities and trained volunteers including availability of licensed HAM radio operators, and b) availability of emergency responder kits to enable timely and effective rescue operation during emergency/disaster situations.

[Audit paragraph 2.5.3 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in

Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

25. While discussing the above para, the Member Secretary, KSDMA stated that the Aapda Mitra program is a Centrally Sponsored Scheme. Training was provided to 200 volunteers selected by KSDMA from the Kottayam District. Subsequently, the Government of India extended the scheme for an additional year and on completing the project the utilization certificate had been issued. Following a review of the pilot project's performance, funds were allocated to the remaining 13 districts of Kerala, and those funds have been fully utilized. Currently, there are approximately 4,500 volunteers Statewide, with their training and insurance coverage duly ensured.

Conclusion/Recommendation

26. No comments

2.6 Revamping of Kerala Fire and Rescue Services Academy

The Director General (Fire and Rescue Services) (DG) requested Government of Kerala (August 2016) to allot ₹98.25 lakh[27] from the savings of the 13th Finance Commission grant-in-aid for revamping F&RS Academy at Viyyur, Thrissur. The proposal included procurement of vital equipment for rescue operation during flood such as Self-Contained Underwater Breathing Apparatus (SCUBA) Set (₹26 lakh),

27 The amount was from fund provided by 13th FC during the period 2010-11 to 2014-15 of which ₹103.97 lakh remained unutilised with KSDMA. The remaining amount of ₹5.72 lakh in the fund balance of KSDMA was approved by GoK (March 2017) to be utilised for making the SEOC Green Energy Compliant.

Breathing Air Compressor (₹ six lakh) etc. Accordingly, GoK accorded Administrative sanction (September 2016) for the proposal and the funds were credited by KSDMA to the treasury account of DG (F&RS) in March 2017.

Audit observed from scrutiny of records at the F&RSD that the funds remained idle with F&RSD until March 2018, when these were resumed by GoK. Further examination revealed that though tenders were invited (MayJune 2018) by F&RSD for the purchase of requisite items in 2018-19, these had to be cancelled (August 2018) as the funds were already revoked by GoK. Nevertheless, even without obtaining Utilisation Certificates from F&RSD, KSDMA recorded the entire amount resumed by GoK as expenditure for the year 2016-17.

Joint physical verification conducted by Audit along with Assistant Director, F&RS Academy (October 2019) revealed severe shortage of equipment, vehicles and infrastructural facilities (Appendix III(2)) in the Academy. With the sparse facilities available in the F&RS Academy, Audit observed that the 3173 trainees who enrolled in Academy during the audit period (2014-19) could not get the benefit of quality training in simulated environment to equip them both mentally and physically for quick response during a crisis situation.

GoK replied (November 2020) that KSDMA had to book the amount as outgo of funds since the amount allotted and released by Government under the supplementary grant was in turn released to F&RSD and the same has subsequently been resumed by Government. The efforts

made by the department to procure items in 2018-19 fell through because the Government did not release the resumed funds mainly due to the adverse ways and means position arising from the floods of 2018. GoK also referred to the audit contention that had the purchases been effected the material could have been utilised for training purposes as hypothetical. The reply is not justifiable as KSDMA should have monitored more closely the utilisation of funds released by it. GoK informed in the Exit conference (January 2021) that the proposal to re-credit the funds to F&RSD and revalidate it for the purposes for which allotted or return the funds to KSDMA for capacity building has been rejected (July 2020) by the State Executive Committee.

Audit notes that the shortage of equipment at the Academy was also accompanied by shortages in Fire and Rescue stations and hence needs immediate attention as Fire and Rescue Services Department, established in 1962 is the dedicated force under Government of Kerala equipped for rescue services during disasters. In exercise of the powers vested in the Disaster Management Act 2005, KSDMA proposes the annual fund requirements to Government of Kerala for Disaster Management. Analysis of records relating to formulation of Annual plans of KSDMA from 2016-17 onwards showed that though regular provision of funds to F&RSD was made in the annual plan proposals of KSDMA and ₹25 crore allotted earlier[28] for the purchase of modern rescue equipment, the equipment in the test-checked fire stations was not adequate to meet the unprecedented flood situation in 2018. The fire

28 between 2009-10 and 2012-13

station at Chengannur, for instance, one of the worst hit areas during 2018 flood did not possess Rubber Dinghy boats, speed fibre boats or scuba sets. Rubber dinghy boats from Tamil Nadu and Odisha had to be depended upon. No high beam lights were available for night rescue operations. Communication devices such as HAM radios were not seen utilised effectively in test-checked districts.

Audit observed that urgent attention needs to be given to reviewing availability of equipment in possession of the Academy and fire stations across the State.

Recommendation 2.6: Priority needs to be given to review the adequacy of equipment, vehicles and infrastructural facilities in the Fire and Rescue Services Academy as well as in Fire and Rescue stations so that the GoK's dedicated force for rescue services may be adequately equipped to handle any flood or other disaster situation.

[Audit paragraph 2.6 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

27. The Committee sought clarification regarding the audit observations related to the renovation of the Kerala Fire and Rescue Service Academy. The Director General of Fire and Rescue Services indicated that the total allocated funds were not completely expended, and the

renovation work was conducted using a portion of those funds. When enquired about the delay in inviting tenders, the Director General explained that the hold up was caused by delays in obtaining estimates from the Public Works Department. He added that the audit report pointed out the insufficiency of facilities including dinghy boats at the Chenganoor fire station during the 2018 floods for rescue operations. He assured the Committee that measures were being taken to address those issues.

Conclusion/Recommendation

28. No comments

2.7. Non-functioning of Virtual Cadre for Disaster Management

The Kerala State Disaster Management Plan (KSDMP) approved (September 2016) by Government of Kerala with its focus on disaster risk reduction in the State, envisaged formation of a Virtual Cadre for Disaster Management. The Virtual Cadre would principally be 15 selected individuals (one from each district and one at the State level) from each department, with at least 20 years or more of service left. The members of this Virtual Cadre would be the departmental nodal officers responsible for liaising and coordinating with KSDMA and DDMAs in disaster management. It was envisaged that the disaster-specific nodal departments through Virtual Cadre would also work in tandem with the State Emergency Operations Centre (SEOC) and District Emergency Operations Centres (DEOC) for ensuring coordinated response to disastrous events.

Departments were to intimate to KSDMA, the names of members nominated to the Virtual Cadre. State Government was to issue an Executive order under Section 16[29] of the DM Act, 2005 formalising[30] the Virtual Cadre once the selection list was approved by the State Executive Committee (SEC). Audit observed the following;

- Consequent upon the formulation of KSDMP in September 2016, GoK issued (November 2017 and February 2018[31]) orders instructing Heads of 26 Departments to furnish details of officials to be included in the Virtual cadre to KSDMA before 31 December 2017. Eight[32] Departments forwarded (between November 2017 and May 2018) the lists of officials to be included in the Virtual Cadre of disaster management. The information furnished by five[33] out of the eight Departments was not in consonance with the criteria stipulated in the Government order with reference to educational qualification, date of entry in service and years of service left. Though the data were returned to the departments seeking rectification, no further response was obtained from the departments.
- KSDMA did not take up with SEC, the matter of approval of the

29 The State Government shall provide the State Authority with such officers, consultants and employees, as it considers necessary, for carrying out the functions of the State Authority

30 Paragraph 5.3 of State Disaster Management Plan

31 Order was issued for including one more Department.

32 i) Commissionerate of Land Revenue, ii) Public Works Buildings, iii) Directorate of Panchayat, iv) Directorate of Health Services, v) Directorate of Mining and Geology, vi) Directorate of Ground Water Department, vii) Directorate of Soil Survey and Soil Conservation and viii) CE Irrigation and Administration

33 i) Directorate of Panchayat, ii) Directorate of Health Services, iii) Directorate of Mining and Geology, iv) Directorate of Soil Survey and Soil Conservation and v) CE Irrigation and Administration

selection lists of the three remaining departments. Consequently, GoK did not issue executive orders under Section 16 of Disaster Management Act, 2005 for formalising the Virtual Cadre.

Government cited (November 2020) insufficient allotment of funds and difficulty in enrolment to a voluntary and non-remunerative service as hurdles in implementation of the scheme and stated that 96 officers from eight departments have been initially provided training and inducted and that more personnel are expected to be inducted subject to availability of funds and willingness of officers.

To the specific question of why lists of officials of the three Departments mentioned above were not presented to SEC and Executive orders issued formalising the cadre, Member Secretary KSDMA replied in the Exit Conference (January 2021) that a prudent examination was required before finalising the cadre.

Audit is of the view that considering the envisaged role of the Virtual Cadre in disaster risk reduction through effective liaising and coordination with KSDMA/ DDMAs and SEOC/ DEOCs, it is imperative that the State gives attention to operationalise effectively the Virtual Cadre across all the departments at the earliest. Since the State Government was to issue an Executive order under Section 16 of the DM Act, 2005 formalising the Virtual Cadre once the selection list was approved by the State Executive Committee, non-approval of a selection list would in effect be reflective of the relative low priority being given to implementation of this item in the State's Disaster Management Plan.

Since the Kerala State Disaster Management Authority currently functions with only 27[34] full time employees, the role that could be potentially played by an active Virtual Cadre during disasters cannot be underestimated.

Recommendation 2.7: Virtual Cadre needs to be formalised and strengthened in the State so that the disaster-specific nodal departments could work in tandem with the State/ District Emergency Operations Centres through the cadre, for ensuring coordinated response to disastrous events.

[Audit paragraph 2.7 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

29. During the Committee's query regarding the audit observation related to the non-functioning of Virtual Cadre for Disaster Management, the Member Secretary, Kerala State Disaster Management Authority provided clarification that the Virtual Cadre represented a systematic approach to integrating disaster management activities across various Departments by employing an average of 15 officials from each Department in Government of Kerala. Training for those officials was conducted in coordination with UNICEF. Many of the States regarded the system as equitable; however, the transfer of personnel emerged as a significant challenge impacting the programme's success.

34 Position as in March 2019

It was determined that personnel with a minimum of 20 years of service should be prioritized; however, currently, none of the Departments have the requisite number of such officials available, resulting in a reduction of personnel from 15 to 7 as recommended by the Head of the Department. Training was subsequently provided with assistance from the Sustainable Environment and Ecological Development Society (SEED). To facilitate the effective implementation of the programme, it is essential to establish institutional memory among the personnel involved. The absence of institutional memory poses substantial difficulties for Departments attempting to execute the programme effectively.

Conclusion/Recommendation

30. No comments

3. Flood Forecasting and Reservoir Operation

Flood Management includes planned engineering measures (structural and non-structural) aimed not only at controlling the flood, but also providing optimum utilisation of stored surplus water during lean seasons. Structural measures include multipurpose reservoirs and retarding structures for storage of flood waters, channel improvements to increase flood carrying capacity of the river, embankments for keeping the water away from flood prone areas, improvements in drainage system etc. which have the effect of restricting the movement of flood water into flood plains. Non-structural measures such as flood forecasting and warning, soil conservation, flood proofing, flood plain zoning etc. largely depend upon how accurately the estimation of future stage or flow of incoming flood and its time sequence at

selected points along the river, could be predicted[35].

The devastating floods in Kerala during August 2018 severely affected 13 of the 14 districts in the State resulting in huge loss of life and property. Kerala received 2,346.60 mm rainfall between 01 June and 19 August 2018, which was about 42 per cent higher than the normal rainfall of 1,649.50 mm during the same period[36]. Further, the rainfall over Kerala during June, July and August 01-19, 2018 was 15 per cent, 18 per cent and 164 per cent respectively above normal (CWC, 2018). As the Performance audit included examining technical aspects which required expert support, Indian Institute of Science (IISc) Bangalore was engaged as Consultant to study the Kerala floods of August 2018, from a hydrological perspective. The focus of the study was the Periyar river basin which covers an area of 5,159.71 square kilometres. The following paragraphs are the findings of Audit including those based on the study undertaken through IISc, Bangalore.

3.1. Adequacy of rain gauges in Periyar basin

Rain gauges[37] are instruments used by meteorologists and hydrologists to gather and measure the amount of liquid precipitation over an area in a predefined period of time. Measurement of rainfall at several critical locations in the basin is extremely important because of the high spatial variability of rainfall. The accuracy of rainfall estimation over a region with significant spatial variability in rainfall is dependent on distribution of rain gauges in the region. Rain gauge density[38], therefore, plays an important role in quantifying the rainfall amount over a region.

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35 Manual on Flood Forecasting, CWC, 1989

36 CWC Report, 2018

37 Rain gauges are also known as udometers, pluviometers, or ombrometers.

38 Rain gauge density is defined as the ratio of the area of the catchment to the number of rain gauges there.

An examination of the existing density of IMD rain gauges[39] in the Periyar basin with respect to norms stipulated by the Bureau of Indian Standards[40] was carried out by IISc, to assess the adequacy of rain gauges in the basin. Figure 3.1 shows the locations of the existing rain gauges and flow gauges in the basin.

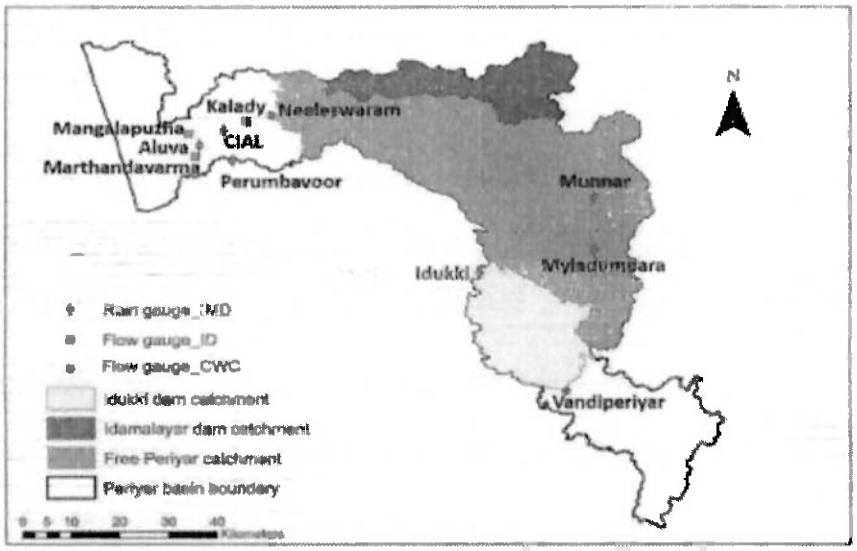

Figure 3.1: Locations of existing rain gauges and flow gauges in the Periyar basin (2019)

(Source: IMD, CWC and Irrigation Department)

The rain gauge density as recommended by BIS code (IS 4987:1994) is given in **Table 3.1**.

Table 3.1: Recommended minimum rain gauge density

Region type	Rain gauge density (sq. km per gauge)
Plains	500
Regions with average elevation of 1000 m above MSL	250–400
Hilly areas with heavy rainfall	150

(Source: BIS Code, IS 4987:1994)

39 IS 5225:1992 provides that the Director General of Meteorology, New Delhi has been designated the sole authority for ensuring the correct rainfall registration in India.

40 IS 4987:1994 Recommendations for establishing network of rain gauge stations.

Periyar basin is characterised largely as a hilly terrain upto Neeleswaram and receives heavy rainfall. Therefore, according to the IS 4987:1994 one rain gauge per 150 sq. km is required in the basin, up to Neeleswaram (Region type III), whereas, the area downstream of Neeleswaram lies in the Region type I (Plains) and therefore requires one rain gauge per 500 sq. km. The Periyar basin is divided into a number of sub-catchments. The details of additional rain gauges needed in the catchments are given in **Table 3.2.**

Table 3.2: Number of IMD rain gauges in place and additional numbers required

Catchment	Area (sq.km)	Density of rain gauge required (sq.km/gauge)	Minimum number of rain gauges required	Existing number of IMD rain gauges	Additional numbers required
Start of the basin boundary till Vandiperiyar	737.61	150	5	0	5
Idukki	569.55	150	4	1	3
Idamalayar	469.49	150	4	0	4
Free Periyar (downstream of Idukki and Idamalayar till Neeleswaram)	2367.22	150	16	2	14
Downstream of Neeleswaram	1015.83	500	3	3	0
Total	**5159.71**		**32**	**6**	**26**

(Source: Kerala Floods 2018, Report of IISc, Bangalore, July 2020)

It is therefore evident that agaist the recommended minimum requirement of 320rain guages in the Periyar basin, only six rain guages were in place. Audit observes that the shortfall of 26 rain gauges in the basin resulted in lack of real time data on spatially distributed rainfall which could have an adverse impact on flood forecasting and alleviation measures.

Additional Chief Secretary, Water Resources Department, GoK, stated (November, 2020) that the Irrigation Department maintains 10 meteorological stations with rain gauges in Periyar basin. Audit was also

informed that installation of 18 Tipping Bucket Rain Gauges was in progress and Government intends to develop a full-fledged inflow forecasting and flood early warning system National Hydrology Project (NHP).

Though agencies like KSEBL, Irrigation Department etc. maintain rain gauges in Periyar basin, IMD informed (February 2021) Audit that only data generated by those gauge stations conforming to IMD standards (measured at 0830 hours IST daily and reported to IMD) is utilised by IMD. Since data from Irrigation Department gauges were not utilised by IMD, they were not considered while assessing the adequacy of rain gauges in Periyar basin. However, as the already installed/ proposed to be installed rain gauges under the NHP could also be useful for increasing the accuracy of rainfall estimation by IMD, the Irrigation Department may examine the feasibility of sharing of data with the IMD for the purpose by ensuring that the gauges conform to IMD specifications. This needs to be prioritised as irregular distribution of rain gauges could create an information gap in time and space, ultimately hindering decision-making.

The Government further replied (April 2021) that the equipment for installing 18 Tipping Bucket Rain Gauges in Periyar basin under National Hydrology Project have IMD specifications and therefore, the data generated by TBRGs of Irrigation Department could be used by the IMD. Nine of these have already been installed and the remaining nine TBRGs will be installed, commissioned and made fully operational by 31 May 2021.

Recommendation 3.1: Adequacy of the number of rain gauges capable of generating real time data in order to ensure accuracy of rainfall estimation may be ensured. System of sharing data from rain gauges with IMD must be put in place at the earliest.

3.2. Adequacy of flow gauge density in Periyar Basin

Flow gauge[41] density helps to determine the minimum network of flow gauges required to avoid serious deficiencies in developing and managing water resources[42]. Adequate flow gauge density is especially important in flood prone regions to provide useful information on flow depth/ discharge to help in operational decisions.

Audit observed that against the requirement of three flow gauges in the 5,159.71 sq.km. Periyar basin as per World Meteorological Organisation 2008 norms (one flow gauge per 1,875 sq.km. hilly terrain), five flow gauges were installed in the Periyar basin by CWC and the Irrigation Department, of which three gauges at Kalady, Mangalapuzha and Marthandavarma are maintained by the Irrigation Department and the other two gauges at Neeleswaram and Vandiperiyar are maintained by the CWC. Thus, the existing number of flow gauges in the basin as a whole, was adequate. However, there was shortfall of one flow gauge in the free Periyar catchment, comprising of 2,367.22 sq.km of hilly terrain. Thus, in addition to the Neeleswaram flow gauge, an additional flow gauge needs to be located just upstream of Bhoothathankettu

41 Flow gauge is a device that measures flow rate of a liquid, gas or steam. It could be measuring, for instance, the velocity of fluid over a known area.

42 Source: World Meteorological Organisation (WMO), 2008.

barrage[43], which is a major control point in the basin, receiving flows from a large free catchment (contributed by Perinjankutty, Pooyamkutty and Muthirapuzha tributaries and overflows/ spills from Idukki, Lower Periyar and Idamalayar dams).

Additional Chief Secretary, Water Resources Department, GoK replied (November 2020 and April 2021) that in addition to the three gauges in the Periyar basin, it is proposed to install three[44] Radar Level Sensors (RLS) under NHP. Once it is fully operational, it is expected that heavy flow from upper catchment of Bhoothathankettu could be measured and observed on real time basis. Chief Engineer, Irrigation Design and Research Board (IDRB) has assured that the RLS, which will provide real time data in every 15 minutes, will be commissioned and made fully operational by 31 May 2021.

[Audit paragraphs 3.1 and 3.2 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

31. During the discussion, the Chief Engineer, Irrigation Design and Research Board & Irrigation and Inter State Water, Thiruvananthapuram informed that according to the available data, the Department maintained 10 rain gauges, while the Indian Meteorological Department (IMD) managed 6 rain gauges within the State during the 2018 floods.

43 IISc Report on Kerala Floods by P P Mujumdar et al
44 at Bhoothathankettu, Malayattoor and Neriyamangalam

However, there were complaints regarding the lack of real-time data from the IMD-operated rain gauges. In response to the findings derived from the 2018 flood event, the National Hydrology Project had thus far installed 18 real-time data rain gauge systems. Additionally, four further real-time data rain gauge systems had been implemented to ensure the acquisition of timely information. In light of the grievances concerning insufficient rain gauge density, inspection of existing 32 stations revealed inadequate representation of rain gauges in only some forest areas of Idukki District.The Chief Engineer assured that accurate rainfall data would be received from all the 32 stations, and in future, data would also be shared from the 18 operational rain gauge systems. Furthermore, a Water Resource Information System had been established to facilitate data sharing among the Kerala State Electricity Board, the IMD, and the Disaster Management Authority.

32. The Principal Accountant General highlighted that the report indicated the need for an additional 26 rain gauges and enquired whether the current number of rain gauges was adequate, as well as if data sharing with the IMD was feasible. In response, the Chief Engineer confirmed that there were 28 rain gauge systems in operation and that they were willing to share data with the IMD. The Principal Accountant General indicated that the response submitted by the Department lacked clarification. Subsequently, the Member Secretary, Kerala State Disaster Management Authority replied that, according to the report furnished to the Central Meteorological Department in 2018, 100

additional automated weather stations were established in Kerala, with 80% of them operating satisfactorily. It was noted that readings from rain gauges installed by the IRDB were being utilized as part of the Intensive Agriculture Development Programme (IADP). However, data from rain gauges implemented by the State Disaster Management Authority and approximately 200 private weather stations in Kerala were deemed unacceptable, as they failed to meet the quality control standards set by the India Meteorological Department (IMD). This data had been utilized by the State Disaster Management Authority solely for observational purposes and not for forecasting applications. Furthermore, the Member Secretary emphasized that data would only be incorporated into the Numerical Weather Prediction System if there is a minimum of ten years of stable observational data, which is not feasible in the context of Kerala. Additional criteria stipulate that the placement area must extend 12 meters in both length and width, and it must be devoid of trees or buildings in the vicinity.

33. During the discussion, the Chief Engineer, Irrigation Design and Research Board & Irrigation and Inter State Water, Thiruvananthapuram reported that in 2018, only three flow gauges were operational. There was a notable shortfall of six gauges at that time. Currently, the total number of flow gauges had increased to nine, thereby improving the capacity for water flow monitoring and management.

Conclusion/Recommendation

34. No comments

3.3. Flood Forecasting Stations not set up in the State

The activity of flood forecasting includes level forecasting and inflow forecasting. Level forecasts are issued once the water level in a river touches a pre-defined warning level (usually one meter below the danger level but dependent on threat perception of the particular location). The level forecasts help user agencies in deciding mitigating measures like evacuation of people and shifting people and their movable properties to safer locations. Inflow forecasting is used by various dam authorities in optimum operation of reservoirs for safe passage of flood downstream as well as to ensure adequate storage in the reservoirs for meeting demand during non-monsoon period.

Audit noticed that CWC requested (November 2011) Government of Kerala to provide the list of reservoirs which required inflow forecasting stations and list of cities/ towns for flood forecasting purpose. CWC confirmed (August 2019) to Audit that GoK did not furnish the details and hence, no Flood Forecasting Stations (FFS) were set up by the CWC in the State. This was despite 275 flood forecasting stations having been set up by CWC across the country by the year 2017.

The Department of Water Resources (WRD) replied (November 2020) that the Irrigation Department had to address specific technical matters such as the technology of flood forecasting proposed to be used, usability of the system in steep, flashy rivers in Kerala. The viability of an effective forecasting system suitable for peculiar terrain of Kerala

was discussed with CWC officials on several occasions.

Audit however noticed that subsequent to floods of 2018, three level forecasting stations and two inflow forecasting stations were installed (2019) by CWC in the State indicating the suitability of the FFS in the State.

The Department informed (April 2021) that the list of flood prone cities/ towns requiring flood forecasting stations and also the list of reservoirs, which need inflow forecasting has been forwarded on 17 April 2021. Government is on course to develop a full-fledged inflow forecasting and a flood early warning system under National Hydrology Project operational in all river basins in Kerala for real time monitoring by installing 99 Tipping bucket Rain Gauges, 56 Radar Level Sensors and 13 Automatic Weather Stations. Equipment including data loggers have been procured and 33 TBRGs, one RLS and seven AWS installed and the remaining would be installed by 31 May 2021.

The failure of GoK to provide list of reservoirs and cities/towns to CWC resulted in non-installation of FFS in the State and resultant deprival of data which State could have utilised for flood forecasting purpose.

[Audit paragraph 3.3 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

35. When the Committee enquired about the above audit obsevation,

the Chief Engineer, Irrigation Design and Research Board & Irrigation and Inter State Water, Thiruvananthapuram explained that the forecasting data from the Central Water Commission (CWC) was only available for the Idukki and Idamalayar projects. Additionally, the CWC acknowledged the request for flood forecasting at Mullaperiyar.

Conclusion/Recommendation

36. No comments

3.4. Non-completion of a project intended for obtaining data required for flood management

The project Modernisation of Hydrology Information System implemented by Irrigation Department, GoK involved supply, installation and commissioning of Real Time Data Acquisition System (RTDAS) capable of delivering real time data on rainfall, streamflow etc. and assuring data retrieval for a specific period without interruption. The objective of RTDAS was to provide reliable hydrological information required for flood/ drought management, water availability and quality management, streamflow forecasting, integrated operations of reservoirs etc.

Based on competitive tender, the work was awarded (April 2014) to the lowest bidder[45] for ₹1.34 crore with time of completion (TOC) as three months (July 2014). The TOC was initially extended up to 25 October 2014 based on the supplier's request. Citing delay in installation of server (to be done by Irrigation Department), it was extended upto 30 September 2016. No further extension of time was provided and ₹30.19

45 M/s. Astra Microwave Products Ltd, Hyderabad

lakh being the cost of 14 Radar Level Sensors (RLS) was paid to the firm in June 2016. Audit observed that though all the equipment were installed, many of them were not functional (status as of August 2020) as detailed in **Table 3.3.**

Table 3.3: Status of Real Time Data Acquisition System

Sl. No.	Item of work	Quantity	Unit rate	Total quoted amount	Status of execution (as of August 2020)
1	Supply, installation, testing and commissioning of Tipping Bucket Rain Gauges (TBRG) with data collection platform consisting of data logger	8	79,080	6,32,640	Data from one TBRG was not being received in the central server.
2	Supply, installation, testing and commissioning of Automatic Weather Stations (AWS) with data collection platform consisting of data logger	19	2,65,300	50,40,700	Data from nine AWS was not being received in the central server.
3	Supply, installation, testing and commissioning of Radar Level Sensors (RLS) in river gauging stations with data collection platform consisting of data logger	18	2,75,100	49,51,800	Data from five RLSs was not being received in the central server.
4	Installation and commissioning of ground station consisting of telemetry GSM/GPRS transmission system and software to evaluate streams of data	1	2,25,000	2,25,000	Commissioned in June 2019
Total (less discount offered two *per cent*)				1,06,33,137	
AMC for five years after two years' warranty period				27,64,200	
Grand total				**1,33,97,337**[46]	

(Source: Data furnished by the Irrigation Department)

The Department had also noticed errors in data received from certain equipment and had intimated Audit that the process of verifying the reliability of data by comparing it with manual data was underway. Audit noticed that though more than five years have elapsed, the objective of obtaining real time hydrological data useful for improving flood management capabilities remained unachieved.

Government replied (November 2020 and April 2021) that even though instruments with IMD calibration and certification were installed, the instruments failed to deliver reliable data on real time basis. Most of the data could not be retrieved through data logger and showed variations

46 The firm had quoted 11.82 and 54.16 per cent less than the estimated amount for equipment and AMC respectively.

when compared with manual reading. Despite Irrigation Department's constant follow-up, the firm did not attend to the same. Notice to the firm was issued on 16 April 2021 for termination of contract and the concerned Chief Engineer has been directed to take steps to blacklist the firm for breach of agreement conditions.

[Audit paragraph 3.4 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

37. During the discussion, the Chief Engineer, Irrigation Design and Research Board & Irrigation and Inter State Water, Thiruvananthapuram submitted that the Department had entrusted M/s. Astra Microwave Products Ltd. with the installation of a Flood Forecasting System. Due to the firm's inadequate response it had been blacklisted and the Department would ensure that the remaining works would be completed promptly.

Conclusion/Recommendation

38. The Committee notices that the project intended for obtaining real time hydrological data useful for improving flood management capabilities remained unachieved even after an elapse of more than five years. Therefore, the Committee directs the Department to complete the remaining works as early as possible and report it to the Committee urgently.

3.5. Inadequacies of State Emergency Operations Centre

3.5.1. Non-availability of data required for the functioning of Decision Support System established in State Emergency Operations Centre

The State Emergency Operations Centre (SEOC) is the research and technology laboratory of KSDMA and is the State nodal office for the collection, compilation and analysis of data received from all Government departments and institutions on a no-cost basis. DM Plan 2016 envisaged SEOC to be equipped with a full-fledged state-of-the-art IT and Communication network with an intelligent Decision Support System (DSS) capable of prediction and early warning of major hydro-meteorological hazards and support for emergency operation.

The work of setting up an Information Technology and Communication System (IT & CS) in SEOC which includes DSS was awarded (April 2016) to Keltron, a State Public Sector Undertaking with the targeted date for completion of work fixed as April 2019. The estimated cost of the project was ₹5.96 crore to be met from the 13th Finance Commission grant. The work was to be completed in three phases. While the first phase involving IT set up, base configuration etc. was completed in January 2017, the second phase which involved development of Decision Support System, Standard Operating Procedure etc. was completed in October 2017. The third phase viz., scaling to the new SEOC building and continued handholding remains to be completed (March 2020). KSDMA stated that 85 per cent of the project was completed and payment of ₹4.54 crore made to Keltron till date (October 2019). The target date

for completion was extended up to 31 March 2020 at the request of Keltron.

According to the Flood Management Organisation of Central Water Commission, flood forecasting requires hydro-meteorological data on real time basis at least hourly or sub-hourly for the parameters of rainfall and water level. According to the pre-development solution design document prepared by M/s. Element Blue[47] for KSDMA, 10 sets of real time data which includes rainfall, temperature, humidity etc. were to be provided by KSDMA.

KSDMA stated (March 2020) that though the DSS was capable of ingesting multiple real time data, KSDMA was unable to enable this part since no real time data was provided by IMD, CWC or Geological Survey of India. Audit examination of records to ascertain reasons for dearth of real time data necessary to make the DSS fully operational, revealed the following.

- None of the 69 manual rain gauges utilised by the Indian Meteorological Department (IMD) generate real time data. Real time data is obtained only from the seven functional Automatic Weather Stations and 10 Automatic Rain Gauges of IMD.
- The 22 rain gauges installed by KSEBL also do not generate real time data.
- Out of the 39 river gauges operated by Central Water Commission, only one generated real time data. However, Audit

47 M/s. Element Blue prepared the solution design document which describes the system requirement, operating environment, system and sub system architecture, files and database design, input formats, output lay-outs detailed designs.

observed that KSDMA had no access to this data, though CWC was sharing data from this telemetric station with the Karnataka State Disaster Monitoring Centre.

- Audit noticed that the DSS was to function on the basis of 10 available data sources which included, inter alia, weather data source (rainfall, temperature, humidity etc.), satellite images and derivatives. water data (reservoir water level, river flow data etc.), seismic data etc. However, Audit observed that historical data available with KSDMA was limited to rainfall, temperature, humidity and dry bulb temperature (provided by IMD).
- The Flood Hazard Susceptibility map prepared by NCESS in 2010 has been configured in the DSS despite it not possessing the necessary characteristics of such a map, as pointed out in Paragraph 2.4 of this Report. Since the DSS looks up in this map for the nearest rainfall scenario and identifies the nearest probability scenario from the look up library and uses it for identifying critical assets[48] and areas needing external assistance[49], the inadequacies of the map would impair the capabilities of the DSS.

Audit noticed that before commencement of the IT and CS project, the State IT department had raised doubts (June 2014) about the availability of data and cost involved in collection of data. KSDMA clarified (July 2014) that weather data (near real time to daily), seismic data (near real

48 critical assets such as schools, hospitals, shelters etc
49 Source: Pre-development solution design document.

time), reservoir data (daily digital from KSEBL) and historical data from IMD and Irrigation Department (stream flow) were available with KSDMA. Being the nodal agency for collection, compilation and analysis of data, it was incumbent upon SEOC to ensure availability of required data for prediction and early warning of major hydro-meteorological hazards and intelligent support for emergency operation. However, as per details furnished to Audit, data presently available with SEOC was limited. The absence of real time/ historical data and an adequate flood hazard map would impair the functioning of the DSS.

Department of Revenue and Disaster Management in its reply dated (December 2020) stated the following points;

- Establishing warning systems and providing disaster alerts are the functions of notified Central agencies under the Disaster Management Act 2005/ NDM Plan and not of KSEOC.
- Decision Support System of KSDMA is not for analysing raw data and generating alerts. KSDMA's function is confined to crisis management in accordance with the magnitude of an event as projected by the notified agencies.
- KSDMA referred to GOs dated 18 October 2019 and 06 May 2020 as examples of KSEOC's efforts for ensuring real time data. Since 2017, it has been engaging with IMD (which has statutory responsibilities laid down in NDM Plan) for sourcing real time data.
- CWC has only one real time monitoring station in the State. It is

the responsibility of CWC to have increased the number after assessing the hazard potential. Kerala was never identified nationally as a priority State for implementation of flood monitoring systems. Detailed demands of KSDMA for improving flood forecasting was placed before CWC (March 2017) and the Rajya Sabha Committee on Petitions (30 May to 02 June 2017).

- One of the fundamental requirements of real time operations is the availability of accurate river flow forecasts. The dilemma of prudent inflow forecasting is reflected in the counter affidavit of Government of India in WP (C) 2996 of 2018 where CWC has admitted the limited scope of riverine flood forecasting systems in Kerala. The technology and science are not developed as yet to implement a pragmatic and usable forecasting system in Kerala's flashy rivers. Until these technical bottlenecks are resolved, it is not possible to determine the feasibility and usability of inflow forecasting and flood forecasting in the rivers of Kerala. Hence, Audit observation that KSDMA/ KSEOC should have such data was contested.
- DSS of KSDMA is a management decision making tool and not meant for such analysis.
- KSDMA possesses data of satellite images, various derivatives such as slope, aspect, NDVI, Seismic Catalogue etc. as well as reservoir data, together with over 60 geospatial data. KSEOC utilised the available data for providing risk maps to districts[50] for

50 by email with maps dated 28.07.2018 from KSEOC to DEOC

enabling crisis management. Maps of immediate threat zones due to any opening of shutters of Cheruthoni dam of Idukki reservoir overlaid with satellite images were provided to DEOCs of Idukki, Thrissur and Ernakulam on 28 July 2018 based on the inundation history of 2013 and rapid assessment of available satellite images.

- The Flood Susceptibility Map of Kerala is accurate enough for all practical purposes and can be used for DM preparedness till such time as CWC is able to provide large scale flood prone area maps.

- KSDMA was in receipt of daily rainfall data from IMD. Seismic data was available real time during the period from KSEB- KSDMA joint project. Reservoir data of KSEBL reservoirs was available in digital format from KSEBL as well as historic data from IMD, Irrigation department and Ground Water department. Inadequacy of real time monitoring systems of Central agencies is a reason for KSEOC developing a system with futuristic data management possibility.

Audit observes that the DM Plan 2016 envisaged SEOC to be equipped with a full-fledged state-of-the-art IT and Communication network with an intelligent Decision Support System (DSS) capable of prediction and early warning of major hydro-meteorological hazards and support for emergency operation. Even two years after the targeted date of completion of April 2019, the system cannot be

relied upon to predict and give early warning of major hydro-meteorological hazards since its effective functioning is dependent on the receipt of externally sourced real time data which is yet to be made available. The IT department of GoK had even before commencement of the project raised doubts about the availability of data for functioning of the DSS. The reply of GoK is silent about how DSS is to be optimally used by KSDMA in the absence of required data and how the State proposes to meet the pressing need of an effective early warning system. The inadequacies of Flood Prone Area Map of the State and the lack of GoK response to the request of CWC to install Flood Forecasting Station have also been discussed in Paragraphs 2.4 and 3.3 of this Report. Prudent project implementation would require the consideration of the likelihood of essential inputs being available in time, for effective functioning of the system and fulfilment of what is stated in the State's Disaster Management Plan.

Recommendation 3.2: Keeping in view the criticality of flood management projects and in order to ensure their successful and time-bound implementation, Government may ensure that projects for procurement/installation of systems meant for flood management such as information systems, decision support system etc.,

(i) are entered into only after fulfilment of a pre-determined common list of prerequisites as well as consideration of aspects such as a) the likelihood of timely availability of input data from all sources including

external sources, b) whether Government would be in a position to meet its commitments such as installations of servers without delay, previous experience of bidders etc. and

(ii) are covered by a stringent monitoring mechanism with clearly defined responsibilities and accountability.

3.5.2. Maintenance of Communication Infrastructure

The Disaster Management Act, 2005[51] envisages that the State Executive Committee would ensure that communication systems are in order. Recognising that communication systems were the first to be affected in the event of a calamity, the Handbook on Disaster Management issued by KSDMA therefore required all Emergency Operations Centres (EOC)[52] to have built-in redundancy of different layers of communication networks for ensuring effective communication system even during the most adverse circumstances. Keeping communication system in order even during the most adverse circumstances would be one of the main functions of the EOC.

Tahsildars of Idukki and Chalakudy Taluks informed Audit that there was total failure of communication infrastructure in their respective areas during the floods of 2018. Assistant Engineer (AE) in charge of Poringalkuthu dam in Thrissur informed Audit that communication

51 Section 22(2)(p) of the Disaster Management Act 2005

52Recognising the need for such a State-level dedicated facility for disaster management, the Government of Kerala (GoK) has established the State Emergency Operations Centre (SEOC). The SEOC is envisaged to cater to varying levels of disasters with a state-of-the-art Decision Support System (DSS), integrated with a multichannel communication network. It has advanced redundant satellite-based communication network (National Disaster Management Services Project) and multi-channel terrestrial communications systems including VHF, GSM, 4G, 3G and broadband internet connectivity. (Paragraph 1 and 2 of the EOCESFP 2015, renamed in 2019 as Orange Book of Disaster Management).

infrastructure in the dam had failed on 16 August 2018 and could be restored only after one week. Similarly, AE of Lower Sholayar dam (Thrissur District) informed Audit that a landslide had occurred during the 2018 floods obstructing the road to dam office and no reliable and uninterrupted communication facility was available in the dam site. The official at the dam site had depended on the mobile network of Tamil Nadu which was available at some distance from the dam. Officials of both the dams intimated Audit that failure of communication network had created difficulty in contacting higher authorities for help and directions. Audit, therefore examined the status of implementation of various projects/ schemes meant for ensuring failsafe communication in the State as availability of reliable communication systems would be integral to flood preparedness.

The Revenue and Disaster Management Department informed (November 2020) that uninterrupted communication systems[53] required in SEOC and DEOC to combat disaster as laid down in the Orange Book include dedicated mobile phone, optical fibre internet, hotline, landphone, Fax, VSAT module, Satellite phones, police wireless, Whatsapp groups, Facebook, Twitter, dedicated email, HAM radio and YouTube channel. The healthy mix of civilian and official communication systems through several media reduces significantly chances of communication failure. When one system fails, another would be used

53 According to the reply of Government there are 16 types of communication systems, however, the reply as well as the Orange Book lists only 14 types of communication system.

and none of them is an always-on system. It acknowledged that GSM, telephonic and internet communication was temporarily disrupted in parts of Idukki due to power failure and optical fibre disconnection and the Cell-sites on Wheels (CoWs) deployed provided the required connectivity. Deployment of communication systems at dam sites was taken care of, adequately by dam owners and management of dams was not a function of KSDMA.

Audit observes that the Disaster Management Act 2005 does not exclude communication systems at dam sites from the purview of the SEC or KSDMA.

The deficiencies in maintenance of effective communication systems, as noticed during the course of audit, are detailed below.

3.5.2.1. National Disaster Management Services

The National Disaster Management Services (NDMS), a project implemented by National Disaster Management Authority, envisaged to provide to States,failsafecommunication infrastructure[54] and technical support[55]. Thus, VSAT[56] phones were installed by BSNL at the SEOC at Thiruvananthapuram and DEOCs at Idukki, Ernakulam and Wayanad

54 NDMS is a grant-in-aid in kind project to establish a satellite-based communication network in all States. In Kerala, the project is implemented in creating satellite-based communication linkages between SEOC and DEOCs of Idukki, Ernakulam and Wayanad. The instrumentation includes VSAT Connectivity, Satellite Phones and HF Radio sets. The satellite-based network was to provide additional redundancy in communication. The project was implemented by SEOC vide GO (Rt) No. 2203/2016/DMD dated 30 March 2016. MoU was entered between the NDMA and Government of Kerala on 05 May 2016 for the implementation of the project with duration of 24 months (EOCESFP 2015, renamed in 2019 as Orange book of Disaster Management). Paragraph 4 of the revised scheme proposal for NDMS pilot project for satellite-based communication network refers to failsafe communication infrastructure.

55 Source: Paragraph 4 of revised scheme proposal for NDMS pilot project for satellite-based communication network.

56 Very small aperture terminal

during March and April 2016 respectively. Satellite phones were also provided to these districts after the floods of 2018 for providing additional redundancy in communication. Government of Kerala also nominated (March 2016) the Member Secretary, KSDMA as the nodal officer for the Project.

Audit examined the status of the VSAT communication system/ satellite phones in the test-checked districts and noted that the system was not completely dependable as seen from the following;

- Audit was informed (October 2019) by the Additional District Magistrate, Idukki that VSAT connection was not working regularly and that voice of the speaker was not audible. The connection was not working from 15 August 2018 and that only after issuing many reminders to SEOC was it repaired in December 2019.

  It is significant that VSAT was not functional in Idukki during the floods of 2018, when terrestrial and mobile communication network in the district had failed. Further, the system in Idukki district became functional after over a year.

- VSAT at DEOC, Ernakulam remained non-functional for about 45 days during January-November 2019. VSAT at DEOC, Wayanad was non-functional in October-November 2019 as per SEOC, Thiruvananthapuram records.

- Audit observed that even in SEOC which commenced operation in its new premises at Thiruvananthapuram from January 2019,

VSAT was re-installed only in November 2019. SEOC could not utilise this communication tool for about 10 months. NDMA also informed SEOC (November 2019) that daily testing of VSAT sites at SEOC, Thiruvananthapuram and DEOC, Idukki indicated either faulty or non-responsive systems and required that these VSAT sites be made functional.

- Audit noticed that though satellite phones had been made available at DEOCs and dams, they would not function indoors and were unreliable during overcast conditions. The inability of Satellite phones to function during adverse weather conditions affects its effectiveness as a means of communication during disaster.
- Joint check conducted by Audit along with departmental officers at DDMA Idukki (25 October 2019) revealed that the satellite phone was non-functional. ADM Idukki cited expiry of validity period of satellite phone connection as a reason for non-functioning of satellite phones.

The Department responded (December 2020) that NDMS is not a fail proof communication system but an alternate communication system along with the other systems provided by KSDMA. Performance of NDMS depends on BSNL for bandwidth and hardware maintenance, ISRO for satellite health, KSEBL for power, weather systems for cloud cover and failure of any of these can result in the system becoming non-functional. Inadequacy of bandwidth was reported to NDMA in December

2016. Ensuring connectivity through ISRO bandwidth was BSNL's responsibility. KSDMA informed BSNL and NDMA in September 2016 that the system was agreed to be commissioned only after imparting necessary training to its engineers and ensuring seamless functioning. Initial handing over of systems occurred only on 05 October 2018 and final handing over on 01 and 02 February, 2019 after training of DEOC and SEOC staff at BSNL. The department stated that Audit was commenting on a non-commissioned system. Since handing over, the system was augmented further and is maintained meticulously. It added that all complaints other than power related, could only be reported to the toll-free number of BSNL. The logbook of VSAT at SEOC indicated that calls were made to DEOC, Idukki on 10 August 2018, 30 August 2018, 14 September 2018 and 19 November 2018. The log also indicated that the system did work prior to and during the flood and the voice of the speaker was clear. As regards the relocation of VSAT to the new SEOC premises after a gap of one year, the department stated that KSDMA took all possible steps to operationalise the VSAT terminal through frequent requests to BSNL and intervention of NDMA. Satellite phones were delivered on 17 August 2018. As it is with any satellite signals, reflectivity interference could affect signals temporarily in cloudy conditions and high solar insolation. Possibility of purchasing antenna to enable indoor use of the device is being explored with BSNL. The nonfunctioning of satellite phone during physical verification was attributed to the lack of support from the service provider who got it

functional on 22 November 2019 after detailed proposal for recharge was received from him on 13 November 2019. The reply added that during the short durations when satellite phones were non-functional, there were other communication systems to supplement the failsafe communication.

Audit observes that the department's response corroborates the audit observations as the NDMS system (VSAT and satellite phone) with all its limitations did not provide assurance of being a fully dependable communication system. The observations of Audit regarding the nonfunctioning of VSAT and satellites phones are based on the remarks provided by end users, i.e., ADM (Disaster Management), Idukki, engineers in dam sites and officials at DEOC. Audit observed that no entries were made in the VSAT log maintained by DEOC, Idukki after 26 March 2018. Further, the reply of Government that functioning of Satellite phone is temporarily affected during cloudy conditions and high solar insolation, is supportive of the audit finding. As regards the Department's contention that commissioning of VSAT had not taken place by the time of the 2018 floods, the fact remains that the system was being relied upon by the end-users from March/ April 2016 and the department itself lists and recognises VSAT module among the effective communication systems followed in KSDMA. As part of its normal time functions, the SEOC was to ensure proper functioning of multi-channel alternate communication systems.[57]

57 Paragraph 4.1 of EOCESFP 2015, renamed in 2019 as Orange Book of Disaster Management

3.5.2.2. Non-functional Very High Frequency Radio communication system

The Department of Revenue and Disaster Management established[58] a network of 379 Very High Frequency (VHF) Radios[59] in the State (2010) for enforcing effective early warning system with an outlay of ₹2.65 crore. VHF radio network of KSDMA is a wireless communication technology similar to that used by the Police Department. The advantages of VHF communication over other forms of communication includes its ability to function in severe weather conditions as the equipment is shock and dust proof, resistant to humidity and able to work with a 12-volt battery.

A survey conducted by Audit in 2013 for inclusion in the Report of CAG[60], had revealed that 82 per cent of the equipment were non-functional, due to improper installation, non-execution of repair works and absence of technically skilled personnel. The letter of Director, Institute of Land and Disaster Management (ILDM) (January 2018) addressed to Additional Chief Secretary, Revenue and Disaster Management, GoK also indicates that VHF network was inactive since its installation. Audit observed that an amount of ₹35 lakh (November 2013) was provided to ILDM for engaging technical staff to revamp[61] the VHF equipment at Collectorate and Taluk level and subsequently 130

58 with the financial assistance of UNDP and the Tsunami Rehabilitation Programme

59 State level – 5, Revenue Divisional Office - 2, District level - 14, Taluks - 63 and vulnerable Village -295.

60 Report of C&AG of India on General and Social Sector, Government of Kerala for the year ended March 2013. The survey was part of Paragraph 3.9 'Unfruitful expenditure on Early Warning Systems'. The paragraph was discussed in PAC and PAC had sought additional details from Revenue and Disaster Management Department.

61 for repairing nine out of 14 VHF supplied to Collectorates, 24 out of 64 VHF supplied to Taluks and three out of five Repeaters.

equipment were repaired. However, the revamping activities were abandoned in November 2016 due to lack of further Government sanction. A revamping proposal of ₹1.28 crore submitted to GoK by ILDM (January 2018) is yet to receive approval (December 2019). VHF equipment which was installed incurring an expenditure of ₹2.65 crore to ensure hassle free communication was not functional during the floods of 2018 in any of the test-checked District Collectorates and Taluks. Deputy Collector (DM) Idukki stated (December 2019) that they were dependent on the VHF maintained by Police for communication during the floods of 2018. Taluks and villages which are involved in ground level relief and rescue works during disaster have to depend mainly on land phones, email, CUG mobile network and a fully functional VHF would be a step towards strengthening the communication network at the ground level.

The Revenue and Disaster Management Department responded (November 2020) that as VHF systems were meant not for day-to-day communication but for use in periods of disaster (unlike in the Police department), they are liable to frequent repairs on account of prolonged idling. VHF systems were used intermittently after the warranty period depending on the periodic repairs. The asset installed in 2008-10 being more than 10 years old had outlived its normal useful life. Any further spending on the asset would result in unfruitful expenditure, hence the decision not to sanction further expenditure and to recommend handing over to the Police department. By preventing

avoidable expenditure on revamp and utilising the wireless phones of the Police personnel for flood management, the 2018 flood situation was managed well by KSDMA and the DDMAs. The department avoided expenditure on a failed and redundant system, it added.

Audit noticed that though Government had provided different types of communications, most of them were vulnerable to failure during a disaster owing to their dependence on internet or terrestrial network. The VHF of Police department had withstood the disaster of 2018 as stated in the paragraph and hence can be considered as a reliable communication network.

The Kerala State Disaster Management Plan, 2016 elaborates the procedure for maintaining the VHF system and ensuring that the system remains functional, it includes daily checking and sorting out any technical issues using the services of Police Telecommunication wing. Hence, the contention of Government that VHF networks were not intended for day-to-day communication purposes but for use during periods of disaster, and equipment were liable for frequent repair on account of prolonged idling, is not acceptable.

Recommendation 3.3: KSDMA may ensure that fail-safe communication infrastructure is available in vital installations such as at dam sites and that a built-in redundancy of different layers of communication capable of functioning during the most adverse circumstances exists in flood-prone locations across the State.

3.5.3. Non-functional state-of-the-art Digital Seismographs

Idukki district in Kerala hosts 17 dams including the 125-year-old Mullaperiyar dam[62]. Consequent to an earthquake of 3.8 M on Richter scale (July 2011) in the Idukki region, GoK decided to establish (August 2011) a state of the art digital system of seismographs in and around Mullaperiyar dam site for obtaining real time Seismic data as the existing equipment were analogue type and incapable of immediate analysis of data. The work was awarded to M/s. Encardio Rites Electronics Pvt. Ltd. (M/s. Encardio) for ₹3.90 crore. The new equipment was capable of providing reliable, compact and portable data. As stated earlier in this Report, the data from the seismographs would also be an input to the Decision Support System being established at the SEOC.

After setting up (March 2014) six digital seismographs and five accelerographs[63] near and around Mullaperiyar dam site[64] for the effective monitoring of seismic activities, GoK further accorded sanction (August 2016) to purchase one full spare set[65] of GURALP seismograph for ₹50.93 lakh for installation at a suitable site within the ILDM premises[66].

Audit observed that though the vendor supplied (December 2016) one full set of GURALP seismograph along with its allied items and the

62 Mullaperiyar dam lies in seismic zone III, where as per the seismic zoning map of India, earthquake of intensity seven in the Richter scale could be expected.

63 An electromagnetic device used to measure acceleration forces

64 Seismographs at Vallakadavu, Meencut, Chottupara, Aladi, Kulamavu and Pamba; Accelerographs at Idukki dam and Vallakadavu observatory in Idukki District

65 Since the spares of any malfunctioning instrument are to be imported, components from the spare instrument could be used as a replacement till M/s. Encardio substitutes the spare.

66 Institute of Land and Disaster Management under Department of Revenue at Thiruvananthapuram which accommodated the SEOC till it was shifted to the new building in January 2019.

instruments, these were not installed and were stored in the KSDMA building. Audit further observed that the warranty period of the six digital seismographs and five accelerographs, set up in March 2014, expired in March 2017. A proposal (March 2017) of the vendor offering a three-year AMC for ₹66.32 lakh was not successfully concluded. Resultant non-maintenance of the equipment possibly led to the seismographs installed in Idukki becoming non-functional since January 2019. No seismic data is being received by the Central Receiving Station (CRS) since then. Sanction accorded by GoK in July 2018 for entering into an AMC with the vendor became infructuous as the vendor M/s. Encardio intimated KSDMA (December 2018) that they had ceased functioning as the distributor for GURALP instruments in India. After inspection of equipment, a new vendor intimated (August 2019) KSDMA that majority of the original equipment had reached its end of life and offered to replace/ repair the faulty instruments for ₹49.50 lakh before entering into an AMC. The offer was not accepted (January 2020) pending receipt of clarifications from the original vendor.

Want of proper maintenance of the seismographs and related equipment resulted in expenditure of ₹3.90 crore becoming infructuous with the State being forced to depend on data from the erstwhile analogue seismograph instead of obtaining real time seismic data. Further, non-installation of the seismograph purchased in December 2016 meant idling of equipment worth ₹50.93 lakh for the last three years in Thiruvananthapuram.

The Revenue and Disaster Management Department in its reply (December 2020) stated as follows;

- The paragraph has nothing to do with the subject matter of preparedness for floods.
- The six digital seismographs and five accelerographs set up in March 2014 were proprietary items. Any repair or AMC had to be through services of the principal/ their authorised dealers in India. Extended warranty period expired in 2017. AMC could not be concluded beyond this period since the authorised dealer ceased to function after December 2018. New vendor after inspection in August 2019 reported that majority of the items had reached their end of life.
- The equipment custodian KSEBL had utilised its internal skills to revitalise and use the system as long as the original equipment continued to work.
- The offer of the new dealer to repair the instruments for ₹49.50 lakh and then enter into AMC did not appear economical, since the equipment had already outlived their normal life.
- Audit conclusion of failure to ensure adequate maintenance resulting in infructuous expenditure was pre-conceived and irrelevant.
- The purpose of collecting seismic data is served by two digital seismographs in the State, one of IMD in Thiruvananthapuram and the second of NCESS at Peechi.

- Audit observation on non-installation of the spare seismograph was not accepted as the spare intended for replacement in the event of failure of one of the already installed seismographs could not be considered as idling equipment.

During the Exit conference (18 January 2021), it was also informed that the seismographs were not for detection of earthquakes in the State. The responsibility of earthquake detection and monitoring is that of IMD and KSDMA is in receipt of such detections that are relevant to the State. The purpose of the KSDMA funded, KSEBL established seismic monitoring system was for confined monitoring of the selected area in Idukki and at a global scale of earthquake detection and monitoring, all the systems deployed in Idukki would only count as one system. Further, under the initiative of KSDMA, the National Centre for Seismology (NCS), New Delhi has deployed one seismograph in Idukki. Therefore, earthquake detection purpose is well served. The system was funded by KSDMA to KSEBL and KSEBL had the responsibility of deploying and maintaining the system ever since the beginning. During the active period of the system, the system worked satisfactorily.

The contention of the Government that the seismographs at Thiruvananthapuram and Peechi are sufficient could not be accepted since while initiating the project proposal by KSEBL, expert opinions from National Geophysical Research Institute (NGRI) and NCESS were obtained by KSEBL and NGRI had opined that any network around a reservoir should be located in such a way that there is minimum

azimuthal gap and a station should be located in the centre of the network for assessing depth resolution of earthquakes. NCESS while underscoring the necessity of the project added that the seismic observatories of IMD and NCESS could complement the proposed network. Further, following mild tremors in Idukki area in February 2020, KSEBL conducted a meeting (March 2020) to assess the situation and it was opined that the observations from the above Seismographs are highly important for the study of seismic behaviour of Idukki region as it has link with the safety of KSEBL dams and hence action is to be taken to initiate reviving the equipment/ system. Audit clarifies that it is based on the linkage to dam safety and possibility of flooding from dam break that this audit observation has been included in this Audit Report. GoK's contention that the spare equipment cannot be considered as idling is also not acceptable as the sanction order for purchase of the spare instrument specifically stated that the spare instrument shall be mounted in the campus of Institute of Land and Disaster Management, Thiruvananthapuram and data received in the present network at the Central Receiving Station at KSDMA.

In the wake of frequent mild tremors which occurred in Idukki during February 2020, KSEBL contacted CWC for expert advice and CWC recommended to constitute an expert group with representation from a few organisations including National Centre for Seismology (NCS), New Delhi. NCS as part of their study installed (March 2020) seismic equipment in Idukki utilising their own funds and the data was streamed

to its Headquarters at New Delhi. KSDMA's contention that the equipment installed by NCS is more than sufficient cannot be accepted since the objective of the subject scheme was to extract real time seismic data which would be relayed to the State's own CRS that could be monitored at close quarters as recommended by NGRI and NCESS. Audit observes that the single seismograph set up in 2020 is not intended to be a substitute for a system of six seismographs and five accelographs in place earlier.

Further, Audit noticed that the situation which warranted the establishment of these seismographs in 2014 still exists as evident from the tremors felt in Idukki as recently as February 2020.

Recommendation 3.4: Keeping in view the role of the seismograph network in Idukki in studying seismic behaviour and their linkage to the safety of dams in the region, Government of Kerala may ensure that the network of seismographs as recommended by NGRI is put in place at the earliest and the agencies concerned receive real time seismic data from these locations.

Reservoir operation

Dams ensure a large number of potential benefits, but are also structures with potential hazards. Any uncontrolled or excessive release of huge amount of water has potential for loss of life and damage to property due to flooding. Of the 59 dams in the State, 17 dams are in Idukki district. Kerala received 2,346.60 mm rainfall between 01 June and 19 August, 2018, which was about 42 per cent

higher than the normal rainfall.

Audit engaged the services of the Indian Institute of Science Bangalore (IISc) to study, from a hydrological perspective, the operations of reservoirs in the Periyar basin, during and immediately preceding the flood period[67]. Salient features of Mullaperiyar, Idukki, Idamalayar, Lower Periyar dams and Bhoothathankettu barrage are given in **Appendix III(3).** While the Mullaperiyar dam is controlled by Tamil Nadu, the Idukki and Idamalayar dams are under the control of KSEBL. Lower Periyar dam is situated downstream of Idukki dam and has a very small capacity compared to the three major dams. Audit findings with regard to reservoir operations are given in succeeding paragraphs.

[Audit paragraphs 3.5, 3.5.1, 3.5.2, 3.5.2.1, 3.5.2.2 and 3.5.3 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

39.When the Committee enquired about the audit observation regarding the non-availability of data required for the functioning of Decision Support System established in State Emergency Operating Centre. The Member Secretary, State Disaster Management Authority clarified that the Decision Support System was being prepared during the time of audit and the Central Agencies had the responsibility of providing prediction and early warning and the mechanisms for ensuring data flow and reception were ascertained. During the flood of 2018, only three of

67 June - August 2018

the seven automated rain gauges were in working condition. But currently, the situation had been improved and the data flow was being ensured. The available data was integrated with more advanced API (Application Programming Interface) system and the datas were avilable from National Sesmic Centre and Indian National Centre for Ocean Information Services and Skymet. The National Disaster Management Plan stated that the responsibility was vested with the Central Authorities to provide forecast information and warning system and the dissemination according to that was entrusted to the State Disaster Management Authority. As a result of preparing such a system, weather warning is now made available in mobile phones. The Committee noticed in the audit observation that KSDMA had stated that 85 percent of the project was completed and payment of ₹4.54 crore made to Keltron as on October, 2019 and the targetted date for completion was extended upto 31st March, 2020 at the request of the Keltron. The Committee enquired whether the project had been completed. The Member Secretary, KSDMA submitted that the said project had been completed and more effective systems were later implemented. Although it was decided to complete the projects in 2018, it was unable to complete due to Okhi in 2017, flood in 2018 and landslides in 2019. Operations on such occassions were not normally carried out as emergency operations were needed to be carried out round the clock. That caused a delay in completion of the project. The liability for delay in that regard had been fixed by Keltron and would pay

the amount after calculating the deduction.

40. Regarding the maintenance of Communication Infrastructure, the Member Secretary, KSDMA explained that normally, in our Country, the communications were effected through devices installed on the Earth, but subsequent to flood in 2018, the Central Government allotted Satellite Zones for Communication. The GSM and VHF systems would be temporarily disrupted due to power failure and optical fibre disconnection etc during flood time. Usage of Low Earth Orbit Satellites Communication could overcome such disadvantages. But it was not common in India. As 100% fake proof communication systems were not available, satellite phones had been provided in Emergency Operation Centres.

41. While discussing the matter, related to National Disaster Management Services, the Member Secretary, KSDMA informed the Committee that VSAT is a fixed facility and steps taken by the State Disaster Management Authority in that regard were very well detailed in the RMT. It was installed in DEOCs in Wayanad, Idukki, Alappuzha and SEOC Thiruvananthapuram and its operations were managed by BSNL, but its operational faults were rectified at Bangalore. The signals from the satellites were not received properly and that could be corrected only in consultation with an expert agency and that was the reason for the delay.

42. When the Committee enquired about the audit observation regarding the non-functional very high frequency radio communication

system, the Member Secretary, KSDMA submitted that VHF system was installed after Tsunami and the Police force had the most effective VHF system and they are shifting to Digital VHF. The Disaster Management Authority had decided not to expend more money for the old systems as the equipment were not maintenance free and they were handled using the equipment of Motorola. Huge amount was demanded for the repairing of equipment when maintenance work was done in 2013.

43. When the Committee enquired about the audit observation, the Member Secretary, KSDMA informed that in 2011, KSEBL received a grant-in-aid from the State Disaster Management Authority to install seismographs during the Mullaperiyar Dam panic. But when new Dam Safety Rules came into force, it was no longer needed. When old devices were used, a single vendor, GURALP, was there for repairing. So a seismograph was kept as spare in order to replace in the event of failure of one of the already installed seismographs. New devices were installed in all stations when Dam Safety Bill had came into force.

Conclusion/Recommendation

44. No comments

3.6. Assessment of impact of dam spillage on flooding in downstream areas

Audit evaluated the relative contributions of the spills from the two major dams, Idukki and Idamalayar, to the flood flow observed at Neeleswaram gauge station, based on observed data. Contribution of the spills from Mullaperiyar dam to the Idukki inflows was also examined. Data on reservoir inflows, power house (PH) discharge, spills,

storage and water levels at the dams, barrage and flow gauges provided by the KSEBL, CWC and Irrigation Department was used to assess the impact of the spills on the floods.

Since observed flow and river level data was available at Neeleswaram gauge station, the spills from the reservoirs were compared with the observed flow at Neeleswaram to assess the impact of spills on the floods. The percentage contribution of the reservoir spills, on a daily scale, to the Neeleswaram gauge station is shown in **Table 3.4.**

Table 3.4: Contribution of daily spills from Idukki and Idamalayar dams to the observed flow at Neeleswaram gauge station

Date	Total observed spills from Idukki and Idamalayar dams (MCM)*	Flow observed at Neeleswaram (MCM)	Contribution of total spills from Idukki and Idamalayar dams to flow at Neeleswaram (*per cent*)[68]
1	2	3	[(2) / (3)] * 100
14-08-2018	91.06	196.13	46.43
15-08-2018	192.47	532.83	36.12
16-08-2018	234.53	793.93	29.54
17-08-2018	185.85	796.44	23.34
18-08-2018	104.11	612.75	16.99

**The spills presented for Idukki and Idamalayar dams for a day correspond to the observed flow during the 24 hours from 7AM on that day to 7AM on the next day.*

(Source: Report of IISc, Bangalore)

The contribution of the spills from Idamalayar and Idukki dams together, to the flows at Neeleswaram gauge station during the period 14 to 18 August 2018 was significant at 46.43 per cent, 36.12 per cent, 29.54 per cent, 23.34 per cent and 16.99 per cent respectively, though as the extreme rainfall event continued for a few days, the contribution of the spills in percentage terms is seen to have declined.

Further, as the spills from the Mullaperiyar dam pass through the Vandiperiyar gauge station and subsequently contribute to the inflows

68 The volume of total spills from the two dams (Idukki and Idamalayar) together is added and its percentage contribution is analysed to the flows at the barrage and Neeleswaram gauge station.

to the Idukki reservoir, the role of spills from Mullaperiyar dam in the escalation of flows at Idukki reservoir during the flood period was also examined as shown in **Table 3.5.**

Table 3.5: Contribution of spills from Mullaperiyar dam to Idukki inflows

Date	Spills from Mullaperiyar dam (MCM)	Inflows observed at Idukki dam (MCM)*	Contribution of spills from Mullaperiyar to Idukki inflows *(per cent)*
1	2	3	[(2) / (3)] * 100
14-08-2018	2.17	84.18	2.58
15-08-2018	46.10	165.06	27.93
16-08-2018	56.74	154.96	36.62
17-08-2018	33.87	111.70	30.32
18-08-2018	33.26	92.51	35.95

**The flow data presented for Idukki and Mullaperiyar dam correspond to the observed flow during the 24 hours from 7AM on that day to 7AM on the next day.*

(Source: Report of IISc, Bangalore)

As evident from the table, the operation of the Mullaperiyar dam had a negligible effect on 14 August but its contribution to the inflows at Idukki was significant during 15 to 18 August (>20 per cent), considering the magnitude of the floods.

Government in its response stated (September 2020) that the contribution of Mullaperiyar dam to the inflows of Idukki during the period of severe floods from 15-18 August 2018 was very significant. Since sudden and unexpected releases from Mullaperiyar dam by Tamil Nadu Government was expected any moment without notice and the quantum of inflow to Idukki reservoir was not known in advance, KSEBL had to provide sufficient flood cushion to ensure safety of the dam as well as controlled release. But for the sudden release of 169.97 MCM of water from Mullaperiyar during the extreme flood days, the attenuation of downstream flood would have been more significant.

The departmental response indicates the need to prioritise and have in place an integrated reservoir management plan, particularly in multi dam

basins. This is significant both because i) the control of reservoir/ dam operations in the State is distributed among KSEBL and the Irrigation department and ii) there is the likely impact of spills from dams under the control of one State in the downstream reservoirs and rivers of another State.

The National Disaster Management Plan lists among the responsibilities of the State (in the context of understanding floods), the implementing and monitoring of flood preparedness, river basin and reservoir management plans including updating rule curves and improving the system of water release from reservoirs.[69]

Audit examined the aspect of the compliance of dam operators to rule curves and the findings are as follows.

3.6.1. Compliance of dam owners to rule curves

A Rule Curve or rule level specifies the storage or empty space to be maintained in a reservoir during different times of the year with the assumption that a reservoir can best satisfy its purposes if these storage levels are maintained. The rule curve as such does not give the amount of water to be released from the reservoir as it will be dependent on the amount of inflows and other extractions. The rule curves are generally derived by operation studies using historic or generated flows[70]. Though it is always desirable to fill a reservoir up to

69 Paragraph 7.2.1, NDMP 2019

70 Upper rule curve represents the water levels to be maintained in the reservoir such that if these are maintained throughout the year, all the demands from the reservoir can be fully met. Keeping the upper rule level below FRL (in monsoon months) can give extra room for flood absorption in the reservoir. Lower rule curve is calculated such that if the storage level goes below this level, only the highest priority demands can be met throughout the year. Generally, the water level in the reservoir is maintained between upper and lower rule curve values.

Full Reservoir Level (FRL) (or upto Maximum Water Level (MWL) during emergency situations, if the dam is structurally stable), it is generally recommended that some spill should be made from the reservoir to keep up the downstream river channel and to avoid encroachment in the river.

During field visit, the IISc team accompanied by Audit personnel were informed by KSEBL that no rule curve was followed for reservoir operations during the flood period. However, Audit noticed that KSEBL had in its possession the Rule Curve framed in 1983 (**Appendix III(4)**). Audit observed that only after the floods of 2018, KSEBL developed new rule curves (KSEBL, 2019) which were updated in 2020 (KSEBL, 2020) though the Operation of Reservoir – Guidelines[71] envisaged (Paragraph 5.0) that the rule curves are to be reviewed constantly and if necessary, modified so as to have the best operation of reservoirs.

Audit made available to IISc, the rule curves (1983 and 2020) for the Idukki dam along with the rule curves for the operation of the Idamalayar reservoir (2020) (**Appendix III(4)**), for carrying out simulations of reservoir operation to determine the volume of spills that would have resulted if these rule curves were followed during the flood period. The simulations of the reservoir operation were carried out for the period June to September 2018. The steps followed in simulating the reservoir operation are given in Appendix III(5). The results of the simulations are given below.

3.6.2. Operation of Idukki reservoir using the 1983 rule curve

71 IS 7323:1994, reaffirmed in1999

The Idukki reservoir operation was simulated with the rule curves developed in the years 1983 (Appendix III(6)) and 2020 (Appendix III(7)) to determine the quantum of spills and to compare these spills with the actual spills that occurred during the 2018 flood period. Table 3.6 shows the observed spills at Idukki dam during the flood period and the spills if the rule curves of 1983 were followed.

Table 3.6: Comparison between actual spills and the spills simulated using the rule curves of 1983 for Idukki dam

Date	Actual spills 2018 (MCM)**	Spills when rule levels are applied (MCM) Initial storage level for simulation (starting date - June 30)		
		Upper Rule Level#	Lower Rule Level*	Actual Storage Level##
14-08-2018	46.26	74.06	0.00	74.06
15-08-2018	111.24	154.94	0.00	154.94
16-08-2018	124.65	144.88	123.82	144.88
17-08-2018	115.20	101.59	101.59	101.59
18-08-2018	70.16	82.72	82.72	82.72
Total	**467.51**	**558.19**	**308.13**	**558.19**

#Start with upper level; Spills computed once storage crosses upper level
*Start with lower level; Spills computed once storage crosses upper level
##Start with actual level; Spills computed once storage crosses upper level
**The actual spills (2018) presented for a particular day are the observed spills during the 24 hours from 7 AM on that day to 7 AM on the next day
(Simulations were carried out from June to September 2018; results for the flood period alone are shown)
(Spills are accounted only if the simulated level exceeds the crest level)

(Source: Report of IISc, Bangalore)

The simulations revealed that the spills from Idukki reservoir during the flood period (14-18 August) would have been higher (558.19 MCM against the actual spills of 467.51 MCM) if the simulations started with the actual storage level or the upper rule level. Thus, for reservoir operations during the floods of 2018, the rule curve of 1983 for Idukki reservoir could not have been relied upon to achieve minimal or no spills. This shows the necessity for ensuring rule curves are regularly updated as required by the National Disaster Management Plan and by

the Reservoir Operation Guidelines[72]. In the case of Idamalayar reservoir, there was no rule curve in place at the time of the 2018 floods for the guidance of dam operators. However, subsequent to the floods of 2018, and based on the Central Water Commission's recommendations in their Study Report on 'Kerala Floods of 2018' to review rule curves for major reservoirs in the State, the existing rule curves were reviewed by KSEB. Subsequently, rule levels as prepared by CWC were approved by the Government of Kerala in May 2020. KSEBL also resolved to give approval to the modified rule levels prepared by CWC for operation of Idukki, Idamalayar, Kakki and Banasurasagar reservoirs. Audit also noted that in the new O&M Manual[73], reservoir operation protocols including "rule curves" were included.

3.6.3. Dam operations based on 2020 rule curves

In order to see how the application of Rule curve of 2020 for Idukki dam operations would impact spills from the reservoir in case a scenario similar to the floods of August 2018 were to happen again, simulation studies were carried out. Simulation of the reservoir operation of Idukki reservoir shows that if it was operated according to the rule curve of 2020, the spills from the reservoir during the flood period would be 531.03 MCM which is higher than the actual spills of 467.51 MCM (14-18 August, 2018) as shown in **Table 3.7.**

72 IS 7323:1994 (Paragraph 5.0) - Rule curves once prepared should be constantly reviewed and modified so as to have the best operation of the reservoirs.

73 As per the guidelines of CWC of January 2018.

Table 3.7: Comparison between actual spills and the spills simulated using the rule curve of 2020 for Idukki dam

Date	Actual spills (2018) (MCM)**	Spills when rule level is applied (MCM) Initial storage level for simulation (starting date -June 10)	
		Rule Level*	Actual Storage Level**
14-08-2018	46.26	68.63	68.63
15-08-2018	111.24	149.51	149.51
16-08-2018	124.65	139.45	139.45
17-08-2018	115.20	96.16	96.16
18-08-2018	70.16	77.29	77.29
Total	**467.51**	**531.03**	**531.03**

*Start with rule level; Spills computed once storage crosses rule level
**Start with actual level; Spills computed once storage crosses rule level
**The actual spills (2018) presented for a particular day are the observed spills during the 24 hours from 7 AM on that day to 7 AM on the next day
(Simulations were carried out from June to September 2018; results for the flood period alone are shown)
(Spills are accounted only if the simulated level exceeds the crest level)

(Source: Report of IISc, Bangalore)

When the exercise was carried out similarly (Appendix III(8)) for Idamalayar dam using the new rule curve of 2020, the study indicated that the spills when reservoir operations were carried out using the rule curve would be lesser than the actual spills in 2018. Table 3.8 shows the observed spills at Idamalayar dam during the flood period and the spills if the rule curve of 2020 is followed.

Table 3.8: Comparison between actual spills and the spills simulated using the rule curve of 2020 for Idamalayar dam

Date	Actual spills (2018) (MCM)**	Spills when rule level is applied (MCM) Initial storage level for simulation (starting date - June 10)	
		Rule Level*	Actual Storage Level**
14-08-2018	44.80	56.13	56.13
15-08-2018	81.23	97.20	97.20
16-08-2018	109.88	85.54	85.54
17-08-2018	70.65	51.24	51.24
18-08-2018	33.94	33.38	33.38
Total	**340.50**	**323.49**	**323.49**

*Start with rule level; Spills computed once storage crosses rule level
**Start with actual level; Spills computed once storage crosses rule level
**The actual spills (2018) presented for a particular day are the observed spills during the 24 hours from 7 AM on that day to 7 AM on the next day
(Simulations were carried out from June to September 2018; results for the flood period alone are shown)
(Spills are accounted only if the simulated level exceeds the crest level)

(Source: Report of IISc, Bangalore)

It is observed that if the Idamalayar reservoir was operated according to the rule curve of 2020, the spills from the reservoir during the flood period (14-18 August, 2018) would be 323.49 MCM (less than the actual spills of 340.50 MCM). Even if the rule curve of 2020 was followed considering the observed actual level on June 10 for initialisation, the

spills during the flood period would still have been 323.49 MCM which is less than the actual spills of 340.50 MCM.

Hence, the simulation studies using the 2020 rule curve for Idamalayar gave a result indicating lesser spills unlike in the case of Idukki.

The Department in its reply (December 2020) said that as per the rule curve of 2020, the water level to be maintained at the Idukki reservoir during 11 to 20 August is 2,386.81 feet with 1,725.71 MCM. This would give a dynamic flood cushion of 270.63 MCM (upto FRL 2,403 ft). The dynamic flood cushion would enable the dam managers to transiently accommodate the heavy inflow into the reservoir during the flooding period and distribute the consequent spill in a regulated manner.

Audit notes that even after a considered decision by KSEBL in consultation with KSDMA in August 2018 to introduce a dynamic flood cushion of four feet below FRL (68.87 MCM) (the rule curve of 1983 for Idukki reservoir permitted KSEBL to store water during the month of August 2018 upto FRL), spills of 467 MCM could not be avoided. Audit also saw that despite such decision, the outflow did exceed inflow in respect of Idamalayar reservoir on two days (16-17 August, 2018) and in respect of Idukki on one day (17 August 2018).

Hence, KSEBL may consider the feasibility of conducting simulation or other studies to ensure that the approved rule curve of 2020 along with provision of dynamic flood cushion would suffice to handle situations similar to the extreme rain event of 2018 with minimal spills, if any.

Need for assurance about the adequacy of the new rule curves is

emphasised also because IISc's studies[74] to examine the effect of reservoir spills on the flood inundation depth and extent showed that if the discharge from Bhoothathankettu barrage consisted only of the runoff generated with heavy rainfall[75], the extent of simulated flood spread would have reduced from 520.04 sq. km to 441.44 sq. km and the maximum simulated depth (with respect to ground level) at Neeleswaram would have reduced from 12.32 m to 9.68 m[76]. KSEBL acknowledged (June 2020) that the 15 per cent reduction of area was a realistic assessment.

The Secretary, Power Department (December 2020) in his response to the audit observation said that the methodology followed by KSEBL in controlling the flow is to operate within the dynamic flood cushion below the FRL and ensure that the levels do not exceed the FRL. Keeping in view this principle, the inflow and outflow in both Idukki and Idamalayar were coordinated. While so coordinating, the sudden inflow without notice from Mullaperiyar as well had to be reckoned. Still the crisis situation was managed well within the prescribed parameters. In Idamalayar on 15 August 2018, the FRL was breached by 0.15 m and the outflow maintained was less than inflow and on 16 August 2018 the FRL was again breached by 0.75m and still the outflow was maintained at a lower level. At that point of time, due to the extreme flood situation, the inflow increased drastically and there was no other alternative but to

74 using HEC-RAS

75 and no contribution from reservoir spills

76 Simulations by IISc using HEC-HMS modelling showed that the flood peaks obtained from the 'with-dam scenario' were attenuated when compared to the virgin simulations (no dam scenario).

increase the outflow to maintain the FRL, considering the safety of dam, as well. The Secretary, Power Department further stated that the position as explained above would indicate that the reservoir operation in the crisis situation was prudently managed and spills were maintained at optimum levels.

The Government vide letter dated 16 April 2021 also informed that in the case of Idamalayar reservoir, the difference between total outflow and total inflow was only 9.86 MCM which is only 2.90 per cent of the total inflow of 338 MCM into this reservoir. Considering the total combined inflows of 946.40 MCM (608.40 + 338), a total combined outflow of 815.37 MCM (excluding PH discharge from Idukki reservoir) was only discharged to the Periyar basin from both reservoirs (between 14 and 18 August 2018). The integrated operation by KSEBL resulted in moderation of 131.03 MCM. KSEBL had let the outflow exceed inflow only in the recession limb of the flood hydrograph which is a standard operation procedure. The response indicated that in Idamalayar, for five hours on 15 August 2018, the outflow was marginally more than the inflow (in the rising limb of the flood hydrograph) but this was before the flood hydrograph's sharp rising and touching its peak inflow. This was unavoidable as Idamalayar reservoir levels breached its FRL and integrated reservoir operation necessitated such release. Attenuation of 1,128 cumecs when the peak inflow of 2,328 cumecs occurred at 03:00 hrs on 16 August 2018 in Idamalayar reservoir was also pointed out. Further, as Idukki PH discharges to the adjacent Muvattupuzha

basin and not to Periyar basin, the same should not be added to the outflows to the Periyar basin.

The departmental reply above seeks to indicate that spills that took place, including outflow exceeding inflow (on two days in the case of Idamalayar reservoir and one in Idukki reservoir), during the August 2018 floods were optimal and acceptable given the circumstances such as inflow from Mullaperiyar without warning and the fact that the outflow exceeded the inflow on the receding limb. However, the KSEB's response that outflow exceeds inflow only in the receding limb, is silent about the downstream conditions. The Neeleswaram CWC Gauge station in the month of August 2018 recorded very high-water flow on 15 and 16 August (as well as on 17 and 18 August). On all these days (15 to 18 August 2018), the flow (refer Table 3.4 of this Report) exceeded 363 MCM/day which was adequate for the river to breach its banks[77]. The water level as measured at Neeleswaram CWC Gauge station on 16, 17 and 18 August was similarly very high at 12.10 m, 12.12 m and 10.55 m respectively when compared to average water level of 4.55 m[78] for the month of August 2018. Thus, the release of water from the dams so close to the peak inflow (even if it was in the recession limb) could aggravate the flood situation downstream. Further, on 17 August 2018, the hourly data indicates that the outflows from Idukki dam exceeded the inflows during 16 hours of the day and on 16 and 17 August, the

77 Response of KSEBL dated June 2020 relying on research article by Dr K.P Sudheer, IIT Madras, et al, 'Role of dams on the floods of August 2018 in Periyar River Basin, Kerala'.

78 Water level on 14 August was 5.91 m as per CWC data.

outflows from Idamalayar reservoir exceeded the inflows for 10 and 21 hours of the day respectively. Besides, even if PH discharge were to be excluded for Idukki, the net inflow would be negative (-3.50 MCM) for Idukki on 17 August. Further, in the case of Idamalayar, though attenuation occurred at peak inflow, the fact is that net inflow over the 14-18 August period was negative (-9.86 MCM). Besides, the Guidelines for operation of spillway gates of Cheruthoni dam (1990) specify that outflow is never to exceed inflow except under emergencies and when the reservoir is to be depleted to the desired level. Thus, Audit feels that it cannot be cited as a standard operating procedure, even during the receding limb of a flood hydrograph, particularly so close to the peak inflow.

Hence, Audit reiterates the need for assurance about the adequacy of the new rule curve along with the provision of dynamic flood cushion given the fact that the frequency of incidents of excessive rainfall and flooding in the State has increased in recent years. As the rainfalls in July 2018 had resulted in an average inflow of 25 MCM per day to Idukki and the average inflow to Idukki between 09 August 2018 and 19 August 2018 was more than three times and of the order of 79 MCM per day, which was unprecedented in the history of the dam, there is an urgent need to be prepared for such extreme rainfall events in the future including through establishment of inflow forecasting stations[79]. The possibility of unscheduled releases from upstream reservoirs also

79 The reservoir level can be better managed by providing a dynamic cushion to moderate flood through meticulous planning by reviewing the reservoir levels and inflow forecast at all time steps. (Source: Rule curve for major reservoirs of KSEB – May 2019)

needs to be considered along with the factoring of downstream conditions. It is desirable further to develop the rule curves keeping in view the integrated operation of the major reservoirs in the basin. Rule curves developed considering various aspects including integrated operation of reservoirs would provide more assurance.

Recommendation 3.5:

a) KSEB may ensure flood release operations for reservoirs are based on approved rule curves which further need to be regularly reviewed and updated.

b) KSEB may conduct simulation or other studies to ensure that the approved rule curves of 2020 for Idukki and Idamalayar would be adequate to handle situations similar to the extreme rainfall event of 2018, without consequential flooding.

c) Feasibility of putting in place rule curves based on integrated operation of reservoirs within an approved time frame must also be considered.

[Audit paragraphs 3.6, 3.6.1, 3.6.2 and 3.6.3 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

45. While considering the audit para regarding the assessment of Impact of dam spillage on flooding in downstream areas, the Deputy Chief Engineer, Research and Dam Safety Organisation, Pallom

informed that based on the order dated 21.05.2020 the rule curve of the major reservoirs had been promptly operated and had updated the rule curves of major reservoirs like Idukki, kakki, Idamalayar and Banasura Sagar. The Principal Accountant General pointed out that the Deparment had not detailed its stand towards the objections pointed out by the Accountant General before detailing actions taken on recommendations and enquired whether the KSEBL had any idea regarding the flow of water to Idukki Dam in the event of a flood situation as happened earlier. The Deputy Chief Engineer, Research and Dam Safety Organisation replied in the positive and added that simulation study and scenario analysis were conducted and steps were being taken for the updation of the rule curve through CWC. To a query of Accountant General, the Deputy Chief Engineer clarified that the updation of rule curve was done in 2020 by KSEB, and that report was scrutinized by the CWC. The AG pointed out that the reply submitted by the Department indicated that they had not planned to manage the sudden and unexpected release of water from Mullaperiyar dam by Tamil Nadu in extreme rainfall scenarios and he enquired about the progress attained in Dam safety after the flood of 2018. The Deputy Chief Engineer, Research and Dam Safety Organisation informed that CWC had developed a forecasting model in that regard and provide an update of forecast regarding rainfall and based on that, the rule curve updation and maintenance of the flood cushion were done by KSEB. When the Accountant General wanted to know more details regarding

the maintenance of flood cushion, the Deputy Chief Engineer, Research and Dam Safety Organization informed that the flood cushion level was properly maintained, it was different at different times and the rule curve was maintained below the full reservoir level.

46. The Accountant General pointed out that the response given by the Administration Department regarding the audit observations were misleading and vague and none of the AG's findings had been properly answered. He added that the Committee could not frame recommendations from such vague and misleading replies. The Deputy Chief Engineer, Research and Dam Safety Organization informed that at present the rule curve is fixed based on evaluating the maximum water level every ten days and maintaining the flood cushion accordingly. The Principal Accountant General pointed out that there is a contradiction in the reply given by the Department regarding the maximum level of the reservoir. Rule curve and flood cushion were operating in Idamalayar Dam but it was not even partially done in Idukki Dam. He added that even though a flood cushion level of around five feet is possible in Idukki, it was not being operated there. The reason for operating a part of the flood cushion in Idamalayar was not clear and enquired whether they were conducting any updation in that regard. The Deputy Chief Engineer, Research and Dam Safety Organization informed that flood cushion was started operating after 2018. At present, rule curve was fixed in every 10 days and flood cushion was maintained accordingly. The Principal Accountant General pointed out that the Department was

not furnishing the details sought for about the flood cushion. The Deputy Chief Engineer, Research and Dam Safety Organization informed that water is held above FRL and below MWL. MWL is above and maintenance is possible even in FRL conditions.

47.The Principal Accountant General pointed out that the flood cushion was operated even without rule curve in Idamalayar and enquired about the reason for not operating flood cushion as per existing rule curve in Idukki dam. The Deputy Chief Engineer, Research and Dam Safety Organisation informed that as per the rule curve of 1983, the dam was at full level and in 2018, the rule curve was operated according to that. He added that less quantity of water has gone out than the actual rule curve otherwise it would have flowed over the dam. The Member Secretary, KSDMA informed that rule curve was fixed by the dam safety authority after the flood of 2018, until then the dam management was done by the dam operators. At present, a Committee was constituted for assessing the compliance of rule curves of dams and its 40th meeting was held recently. As per CWC recommendation, rule curve is sufficient only for dams above 200 mcm but in Kerala rule curve was maintained even below that level and flood cushion was not obtained in those dams. Even six hours of continuous rain would raise the water level beyond the expectations and the rule curves were prepared by adopting precautionary principles in a manageable manner and it also had an index. In continuation of that procedures, KSEBL had installed a siren system in their major dams. He added that no warning system

could be put in place in Mullaperiyar and similar case also existed in Peringalkuth. He further stated that however, all possible mechanisms were being put in place within the limits.

48. When asked about the observation of the Accountant General regarding the consideration of Integrated Reservoir Management Plan in the State, the Chief Engineer, Irrigation Design & Research Board & Irrigation and Inter State Water informed that after the flood, a project had been envisaged for the installation of flood alerting system and Integrated Reservoir Operation System at Periyar Basin. Based on various forecasts from within the country and outside, the forecasting of the expected rainfall in our catchment area had been done and the relevant informations were shared with KSEBL and Disaster Management Authority. He added that as per the request, CWC had agreed to operate a forecasting system in the upper catchment area of Mullaperiyar as things could be shared only at a specific point in Idukki and by considering all the inputs as per forecast the dam related activities would be implemented by the Irrigation Department.

49. while considering the audit para regarding the operation of Idukki reservoir using the 1983 rule curve, the Chief Engineer, Irrigation Design and Research Board & Irrigation and Inter State Water, Thiruvananthapuram informed that the said matter had been discussed earlier.

50. While considering the audit para regarding Dam operations based on 2020 rule curve, the Deputy Chief Engineer, Research & Dam safety

Organization submitted that as per the existing order, water is held and released only after checking the quantity and density of rainfall at the downstream. The Principal Accountant General pointed out that the current status furnished may be correct but the audit remarks were about the release of water in the past and the report clearly mentioned that despite the knowledge of the downstream conditions which were totally saturated, the water was released without considering any possibility of high tides. The Deputy Chief Engineer, Research & Dam safety Organisation clarified that in order to manage the flood of 2018, water had to be released through the Idamalayar Dam.

Conclusion/Recommendation

51. No comments

3.7. Siltation of reservoirs and reduction in storage capacity

Dams and Reservoirs are subject to siltation. Sedimentation causes loss of active storage volume, and thus reduced ability to compensate for outflows for hydro power, irrigation, drinking water and flood retention. Uncontrolled deforestation, forest-fires, overgrazing, improper methods of tillage, unwise agriculture practices and other activities are mainly responsible for accelerated soil erosion which causes siltation in dams. Paragraph 7.10 of Reservoir Operation Guidelines[80] issued by the Bureau of Indian Standards requires capacity surveys of reservoirs to be undertaken once in three to five years or when the loss of capacity was five per cent, whichever was earlier.

80 IS 7323:1994, Paragraph 7.10

- Audit observed that of the 18 reservoirs[81] under the ownership of KSEBL, sedimentation studies of only 11[82] were carried out during the period from 1989 to 2011. As on the date of audit (August 2019), no capacity surveys or sedimentation studies were conducted in any of the KSEBL reservoirs after 2011. Though the sedimentation surveys (in 2007 and 1995 respectively) indicated significant capacity loss as in Kallarkutty dam (47 per cent of gross storage in 45 years) and Anayirankal reservoir (30.92 per cent in 33 years), KSEBL had not conducted any further study to assess the change in silt deposit and reduction in the capacity of the dams. Though KSEBL identified (2010) six dams[83] for conducting desiltation, none of them had been desilted till the date of audit (August 2019).

Secretary, Power Department stated (September 2020) that the live storage in five major reservoirs viz. Idukki, Idamalayar, Kakki, Banasurasagar and Sholayar (out of 18 reservoirs[84]) constitutes 92.27 per cent. Siltation is negligible in these major reservoirs as its annual storage loss is less than 0.2 per cent as per the sedimentation studies conducted through various agencies. In respect of the eight small reservoirs for which studies were conducted, desilting could not be carried out due to difficulty in

81 Eighteen storage reservoirs which are formed under 32 dams.
82 Kakki, Kallarkutty, Lower Periyar, Ponmudy, Poringalkuthu, Kundala, Madupetty, Anayirankal, Pamba, Kuttiadi, Idukki and Idamalayar reservoirs
83 Lower Periyar, Kallarkutty, Ayyappancovil and Kulamavu area of Idukki Hydro Electric Project, Anayirankal, Kundala and Madupetty Reservoirs
84 with live storage capacities ranging from 0.39 to 1460 MCM

depositing removed silt and obtaining permission from Forest Department. The Handbook on assessing and managing reservoir sedimentation published by CWC in February 2019 indicates that the annual storage loss due to sedimentation is significantly low in Kerala reservoirs.

Audit observes that the statement that sedimentation in the five major KSEBL reservoirs is negligible is not based on any recent study or assessment (through CWC or otherwise) as sedimentation assessment of Idukki, Idamalayar, Kakki and Sholayar were conducted during 2004, 2011, 1999 and 2003 respectively. In respect of Banasurasagar reservoir, commissioned during 2005, no sedimentation study is seen conducted. Thus, 9 to 20 years have elapsed since conduct of capacity survey or sedimentation study, even though Reservoir operation guidelines (IS 7323:1994) provide for capacity survey every three to five years.

Kerala State Electricity Board Ltd. informed vide letter dated 01 February 2021 that sedimentation study had been repeated for Poringalkuthu and Kundala reservoirs in 2020. KSEBL also completed sedimentation surveys for five more reservoirs viz. Kallarkutty, Madupetty, Ponmudy, Anayirankal and Sengulam in 2020 but reports of the survey are awaited. Proposals for conducting sedimentation studies for the remaining reservoirs are now included under Dam Rehabilitation and Improvement

Project (DRIP) - II and submitted to CWC for their approval. Chief Engineer (Civil – Dam Safety and DRIP) further stated (February 2021) in the backdrop of the 2018 floods that it was decided to carry out the sedimentation study for Idukki, Idamalayar, Kakki, Banasurasagar and Sholayar reservoirs and the same is included in Dam Rehabilitation and Improvement Project-II.

- Audit observed that the position was slightly better in the case of 20 reservoirs under the control of the Water Resources Department. Siltation study was conducted in respect of all these reservoirs. The study revealed significant levels of siltation in Aruvikkara reservoir (43 per cent), Mangalam reservoir (21.98 per cent), Peppara reservoir (21.70 per cent) etc. However, desiltation activities were not undertaken in any of these reservoirs. Though sanction was accorded (September 2017) by GoK for desiltation of Mangalam and Chulliyar reservoirs, the works were yet to commence as of the date of audit (November 2019).

In its reply, the Water Resources Department (November 2020) stated that silting was generally less in Irrigation dams. However, Audit observed that sedimentation in Peppara, Mangalam and Kanjirampuzha reservoirs of 21.70, 21.98 and 21.27 per cent of its storage capacity was significant.

During the Exit Conference (02 February 2021) and subsequently, vide letter from ACS, Water Resources Department dated 19 April 2021,

Audit was informed that the desilting of Mangalam dam commenced[85] in the first week of December 2020 and that of Meenkara, Valayar and Chulliyar reservoirs entrusted to Kerala State Mineral Development Corporation Ltd. and Kerala Irrigation Infrastructure Development Corporation. With respect to Kanjirappuzha reservoir, bathymetric survey has been completed. Administrative sanction was accorded for the desiltation of Aruvikkara reservoir in January 2021 and two bids received are under consideration of the High-Level Empowered Committee. Further, though all efforts are taken to get the dams desilted, as the participation in tendering process was very low, the works had to be retendered more than once. ACS also stated that with the constitution of River Basin Conservation and Management Authority, the coordination work could be institutionalised and turned into a regular process.

Recommendation 3.6: In view of the possible loss of active storage volume of dams through sedimentation and its consequential adverse impact on flood control, KSEB and Irrigation Department may ensure that sedimentation studies as prescribed in Reservoir Operation Guidelines issued by Bureau of Indian Standards are conducted and timely action taken to arrest the capacity loss of reservoirs.

[Audit paragraph 3.7 contained in the Report of the Comptroller & Auditor General of India on Preparedness and Response to floods in Kerala]

[Notes received from the Government on the above audit paragraph

85 ACS, WRD reply dated 19 April 2021 indicated that work for desilting Mangalam dam is a three- year long project which started on 17 December 2020. As on 10 April 2021, 0.098 MCM sediments (3.32 per cent) removed out of a total estimated quantity of 2.95 MCM

are included as Appendix-II]

Excerpts from the discussion of the committee with officials concerned

52. While considering the audit para regarding siltation of reservoirs and reduction in storage capacity, the Deputy Chief Engineer submitted that the bathymetric survey conducted by KSEBL in 16 dams showed that out of sixteen dams, the maximum sediments were found in Vellathuval and Kallarkutty dams and 74 per cent sediments were found in Vellathuval and 40 percent in Kallarkutty and there was no siltation issues related to major reservoirs and the desiltation projects of Vellathuval and Kallarkutty had already been approved. To a query of the Committee regarding the desiltaion of pazhassi dam, the Chief Engineer, Irrigation and Administration explained that the desiltation projects of Mangalam, Chulliyar, Walayar and Meenkara dams were in progress and arrangements for desiltation works had also been made in Aruvikkara dam. Bathymetric Survey in connection with the desiltation of Malampuazha, Karapuzha, Pazhassi, Malankara and Maniyar had already been carried out and had started the preparation of DPR related to soil exploration works and it would take minimum six months to complete the work. When the Committee enquired whether the desiltation of any dams had completed, the Chief Engineer, Irrigation and Administration replied in the negative and added that the desiltation work of Mangalam dam could not be completed due to COVID-19 pandemic and the said work was terminated under risk and cost. The case filed by NCL I', the implementing agency in connection with that was pending in Hyderabad court. The Principal Accountant General pointed out that the details in connection with the performance of dam after the desiltation had not been provided. The Chief Engineer, Irrigation and Administration further clarified that currently, the minimum distance for sample collection is 50X50 meters and it could be increased up to maximum 200X200 and around 200 soil samples needed to be collected from Malampuzha Dam.

53. The Additional Chief Secretary, Power Department informed that studies were being conducted only on how to store water in case of flooding. But Studies needed to be done on how water flows underground. The Minister had called a meeting regarding conducting a

study on how a dam break would affect other dams. He added that if two TMC of water was brought from Mullaperiyar to Gavi, more water would be available to Idukki and electricity would be generated. He suggested that all those possibilities should be considered and an authoritative study should be conducted in that regard and such type of study is significant in the context of the Wayanad disaster. He further stated that the Forest Department and KSEBL had been instructed to study how the dams would be affected if there was a possibility of landslides or other such incidents and to take necessary remedial action in that regard.

Conclusion/Recommendation

54. No comments

SUNNY JOSEPH,
Chairperson,
Committee on Public Accounts.

Thiruvananthapuram,
28th January, 2026.

APPENDIX I

SUMMARY OF MAIN CONCLUSION/RECOMMENDATION

Sl No	Para No	Deaprtment concerned	Conclusion/Recommendation
1	6	Water Resources	The Committee expresses its concern over the lethargy of the Department in addressing matters such as delay in finalising the State level Master Plan for water resources development and the formation of the State-Level River Basin Conservation and Management Authority. The Committee directs that the formulation of a State-Level Master Plan for Water Resources development and framing of master plans for all major rivers should be ensured by the Government in a timely manner.
2	7	Water Resources	The Committee opines that undue delay in setting up of RBCMA is not acceptable and calls for immediate steps to constitute River Basin Conservation and Management Authority within a specific time frame.
3	17	Revenue and Disaster Management	The Committee directs to submit a report on the action taken by the Department to ensure the availability of large scale flood hazard maps for the identification of the risk prone areas and to prioritise

			response efforts.
4	38	Revenue and Disaster Management	The Committee notices that the project intended for obtaining real time hydrological data useful for improving flood management capabilities remained unachieved even after an elapse of more than five years. Therefore, the Committee directs the Department to complete the remaining works as early as possible and report it to the Committee urgently.

Notes furnished by the Department

Remedial Measures Taken statement submitted b the Public Accounts Committee (2021-23) with rega the Performance Audit Report of the C&AG on 'Preparedness and Response to Floods in Kerala'

Introduction

Accountant General, Kerala conducted a performance audit on 'Preparedness and response to floods in Kerala' with the objective to assess whether the Government's planning and implementation of flood management measures were effective to minimise the magnitude of losses due to floods. Study was conducted against the backdrop of the unprecedented Kerala Floods 2018 and the observations made in the report with respect to the dam operation are based on the simulation study performed by the Indian Institute of Science, Bangalore.

Irrigation Department owns 16 dams. Based on the unique design characteristics of each dam, operation and maintenance manuals were developed for its operation, regular maintenance and inspection activities. Reservoir operations during the heavy rainfall of July and August of 2018 were purely based on weather forecast, quantum of instantaneous inflows estimated in real time using the reservoir water levels, reservoir capacity levels determined as per O&M manuals and design parameters of the dams. At this extreme rainfall situation, Water Resources Department had carried out the reservoir operations prudently to safeguard and secure the lives and livelihood of the people. Spills from the dams of WRD were optimal in comparison with the heavy inflow volumes observed during the flood period and have no impact on exacerbating floods.

Data on Full Reservoir Level (FRL), storage capacity at FRL, Maximum Water Level (MWL), date of opening of the dam and the corresponding reservoir water level pertaining to all the 16 dams under Irrigation Department during 2018 floods are shown in **table 1:**

Table 1

Sl No.	Dam	Full Reservoir Level (FRL) in meter	storage capacity at FRL in MCM	Maximum Water Level (MWL) in meter	Date of opening of the dam	Reservoir level at the time of opening
1	Malampuzha	115.06	226	115.06	01.08.2018	114.86
2	Neyyar	84.75	106.25	84.75	14.06.2018	84
3	Kallada	115.82	504.92	116.73	19.07.2018	114.56
4	Kanjirapuzha	97.5	70.8274	97.5	15.05.2018	
5	Kuttiyadi	44.41	120.52	44.41	14.06.2018	39.80
6	Pothundi	108.204	43.891	108.204	31.07.2018	107.79
7	Mangalam	77.88	25.494	77.88	14.06.2018	77.30
8	Vazhani	62.48	18	62.48	02.08.2018	62.07
9	Peechi	79.25	94.946	79.25	27.07.2018	78.77
10	Walayar	203	18.4	203	14.08.2018	202.29
11	Meenkara	156.36	11.30	156.36	14.08.2018	155.9
12	Chulliyar	154.08	13.7	154.08	14.08.2018	153.8
13	Chimmony	79.4	176.78	79.7	10.08.2018	75.90
14	Malankara	42	37	43	10.07.2018	41.10
15	Karappuzha	763	76.5	764	26.05.2018	74.80
16	Siruvani	878.50	25	881.5	10.08.2018	877.93

{In the Study Report on Kerala Floods of August 2018 by the Central Water Commission, it was stressed that "August 2018 flood in Kerala was due to high intensity rainfall from 8-9, August 2018 and 15-17, August 2018. Abnormal rainfall of 15- 17, August 2018 resulted in heavy flooding in Periyar, Pamba, Chalakudi and Bharatpuzha sub-basins of Kerala. As per IMD, total rainfall occurred in Kerala from 1 August 2018 to 19 August 2018 was about 758.6 mm, which is 164% higher than the normal rainfall of 287.6 mm. The rainfall during 15-17, August 2018 was almost comparable to the historical 16-18, July 1924 rainfall of Kerala, particularly in Periyar, Pamba, Chalakudi and Bharatpuzha sub-basins"}

From table 1, it can be seen that all the dams were opened before the

water reaches the Full Reservoir Level. The strategy of Government was to discharge the water from reservoirs before the possible flood in order to avoid a flood peak downstream as evident from the reservoir levels at the time of opening and the date of opening of respective dams. The strategy helped attenuate the flood impact. The objective of Water Resources Department was to minimise the spills in a possible flood event so as to safeguard critical assets. Only 5 dams viz. Walayar, Chulliyar, Meenkara, Chimmony and Siruvani were opened during the peak flooding period i.e. in between 10.08.2018 and 14.08.2018. Out of these five dams, each of Walayar, Chulliyar, Meenkara and Siruvani have storage capacity below 26 MCM. The date of opening of the dams under the Water Resources Department clearly shows that the department have acted timely and dam operations were carried out prudently in accordance with rainfall alerts and quantum of inflow so as to ensure safe and controlled spill of floodwater.

The audit had conducted simulation studies with respect to the operation of Idukki and Idamalayar dams during the period from 14.08.2018 to 18.08.2018 **(Paragraph No. 3.6- Assessment of impact of dam spillage on flooding in downstream areas)** and is trying to prove that *'the reservoir spills contributed very significantly towards the floods'*. The study was solely relied on data pertaining to the spills from the reservoirs and the flow observed at gauge stations, leaving the actual precipitation levels and inflow volume at the periphery. The observations made in the audit report cannot be accurate unless the data on the actual precipitation levels and inflow volume are meticulously analysed, particularly for the period from 1st August to 19th August.

Following factors have also not been taken into consideration by the audit:

1. Dam Safety aspects of structural damage to the Dam in the event of over spill is not seen analyzed. The integrated dam reservoir operations carried out by the Water Resources department and KSEB Ltd with daily monitoring by SDMA handling crisis management during floods has not been taken into account.

2. In the CWC report on Kerala Floods 2018, it was noted that the runoff

generated from Pamba, Manimala, Achenkovil and Meenachil rivers during 15-17, August 2018 rainfall was about 1.63 BCM against the 0.6 BCM carrying capacity of Vembanad lake. Crucial aspects such as the carrying capacity of lakes and rivers in comparison with the runoff generated during high flood periods has not been taken into consideration.

The Central Water Commission in its Study Report on Kerala Floods of August 2018 specified that "the release from reservoirs had only minor role in flood augmentation as released volume from the reservoirs were almost similar to inflow volumes and even with the 75 percent filled reservoir conditions, the current flood could not have been mitigated as 1-day rainfall in majority of the area was more than 200 mm and severe rainfall continued for 3 to 4 days". It was also rightly pointed out that, "had the reservoir been a few feet below Full Reservoir Level, the flooding conditions would have not changed much, as the severe rainfall continued for 3 days and even for 4 days at majority of the places, and in any case it would have been necessary to release from the reservoirs after 1st day of the extreme rainfall". In the case of dams owned by WRD, reservoir levels were always maintained below FRL and the quantum of outflow never exceeded the inflow volume. There was no case of sudden or unexpected spillage from these reservoirs. Water Resource Department was also aware that under a scenario of high rainfall prediction it was not practical to allow the water level to go beyond FRL. Therefore the department was against the idea of utilising the flood cushion available for certain dams since the flood cushion can be maintained only for a short interval under extreme weather conditions.

Management of dam safety and operations were satisfactorily carried out by the Water Resources Department with the data on instantaneous inflows estimated in real time using the reservoir water level, reservoir level storage capacity, rainfall alerts and the design parameters of the dams. Remedial measures taken statement on audit paragraphs relating to Water Resources Department are narrated in **table 2.**

Table 2

Audit paragraph	Reply
Paragraph 2.1 Inadequate provision for flood management in the State Water Policy (2008) Water Policy of Government of India, which was formulated in 1987 and revised in 2002 & 2012, provides for preparedness to flood, modernization of flood forecasting using real time data acquisition system linked to forecasting model, evolving and implementing operating procedures for reservoirs in order to have flood cushion, increasing preparedness for sudden and unexpected floods, etc. But the Government of Kerala has not incorporated the flood management provisions in the State Water policy formulated in the year 2008. Non-inclusion of elements of flood control	The audit observation that the State of Kerala did not give priority to flood management in the State, was made by the C&AG based on a comparison between the provisions for flood preparedness in the National Water Policy of 2012 and the State Water Policy of 2008. The observation is not true because the State had given emphasis to flood preparedness in the past irrespective of the position that whether there were provisions for flood preparedness in the State Water Policy 2008 or not. 131 rain gauges, 54 river gauge stations and 9 fully automatic climatic stations, which were set up under the National Hydrology Project, were operational in the State prior to the mega floods of 2018. Water Resources Department had employed Gauge Readers for taking the measurements recorded in the gauging devices on a real time basis. This shows that the State did take measures for flood forecasting and was always vigilant in formulating plans for flood control. **Reason for not including adequate provisions for flood management in the State Water Policy at the time of policy formulation.** Kerala State Water Policy was formulated in the year 2008. The State of Kerala never experienced a mega flood as that of 2018 in yesteryears and in the memory of current two to three generations and is needless to say that is the reason for the drafting Committee not to include adequate provisions for flood preparedness in the State Water policy 2008.

measures in the State Water Policy was indicative of the low priority given to flood management in the State. **Recommendation of C&AG** *'Government of Kerala may consider revision of the State Water Policy to include aspects relating to flood management, in line with the National Water Policy and after considering the specific requirements of the State'.*	**Inclusion of provisions for flood preparedness in the State Water policy and the Kerala floods of 2018.** It is an undisputed fact that the mere incorporation of provisions for flood management in the State Water Policy could not have prevented the floods of 2018 as such was the extent of the fury of the flood. As per the hydrological study conducted by the Central Water Commission in September 2018, it was found that the 2018 flood was almost comparable to the severest rainfall of July 1924 of Devikulam. The severest rainfall of such a high magnitude had happened after a huge interval of 94 years and this has made the heavy flood unpredictable. It was stated in the report of the CWC on 'Kerala Flood and Solutions' that the 'return period of flood event from 15th to 17th of August 2018 was above 100 year return period flood i.e. having probability less than 1%, while the flood event from 8th to 10th of August 2018 was above 25 year return period flood i.e. having probability more than 4%'. The Central Water Commission in its Study Report on 'Kerala Floods of August 2018' as 'unprecedented' and specified that "the release from reservoirs had only minor role in flood augmentation as released volume from the reservoirs were almost similar to inflow volumes and even with the 75 percent filled reservoir conditions, the current flood could not have been mitigated as 1-day rainfall in majority of the area was more than 200 mm and severe rainfall continued for 3 to 4 days". Unprecedented heavy rainfall events in the month of August 2018 made the situation worst giving no opportunity to absorb the

flood waters in major reservoirs. Despite a very long shore line, reasonable river bank height and presence of large number of reservoirs, the flood water could not be contained within the river banks and there was large spillage of water in lower reaches of river Periyar and low lying areas of other basins as well as Vembanad Lake. It could be said that if a heavy rain fall of identical magnitude happens in the future, similar kind of flooding will definitely occur. As stated earlier, the State of Kerala had maintained flood forecasting stations at the time of 2018 floods and the data generated from these devices had helped in formulating plans for dam operation and issuing flood alerts to the public. It is clear that the absence of adequate provisions for flood management in the State Water Policy did not have an impact on the flood management strategies of the State.

Strengthening of flood forecasting mechanism in the post flood scenario

As aforementioned, flood forecasting stations were functiong in various river basins in the State prior to 2018 floods. In order to equip the State to contain possible future flood events, Government of Kerala developed a full-fledged inflow forecasting and flood early warning system with real time monitoring operational in all river basins through Tipping Bucket Rain Gauges, Radar Level Sensors and Automatic Weather Stations. Out of a total of 168 flood early warning systems purchased already, 97 Tipping Bucket Rain Gauges, 46 Radar Level Sensors and 12 Automatic Weather Stations

were installed. Remaining 13 equipments will soon be installed.

Framing of operation and maintenance manuals for reservoirs

Water Resources Department owns 16 dams. With respect to the audit observation that the State Water Policy should have provision for evolving and implementing operating procedures for reservoirs, it is to be noted that the WRD had already developed O&M manuals for operation and regular maintenance of all dams and inspection activities based on the unique design characteristics of each dam.

Providing Flood Cushion for reservoirs

With respect to the audit remark that the dam operation and maintenance manuals should provide for 'flood cushion', it may be noted that all the dams under WRD have less storage capacity and limited catchment area except Kallada and Malampuzha dams, which have storage capacity beyond 200 MCM. Details of storage capacity and catchment area of 16 dams are shown below:

Sl No.	Dam	storage capacity at Full Reservoir Level (FRL) in MCM	Catchment area (Sq. Km)	Flood Cushion (in Meter)
1	Malampuzha	226	147.63	-
2	Neyyar	106.25	140	-
3	Kallada	504.92	549	0.91

4	Kanjirapuzha	70.8274	70	-
5	Kuttiyadi	120.52	108.78	-
6	Pothundi	43.891	30.82	-
7	Mangalam	25.494	48.85	-
8	Vazhani	18	20.72	-
9	Peechi	94.946	107.09	-
10	Walayar	18.4	106.355	-
11	Meenkara	11.30	90.65	-
12	Chulliyar	13.7	27.8	-
13	Chimmony	176.78	72.13	0.3
14	Malankara	37	153.5	1
15	Karappuzha	76.5	62	1
16	Siruvani	25	22.47	3

At present flood cushion is available for 5 dams. During the heavy floods of 2018, Water Resource Department was against the idea of utilising the flood cushion since these dams have less storage capacity and the flood cushion can be maintained only for a short interval under extreme weather conditions.

Revision of State Water Policy 2008

As per G.O (Rt) No. 24/2021/WRD dated 12.01.2021, drafting Committee for formulating the revised State Water Policy was reconstituted. The drafting Committee has submitted a revised draft of the amended State Water Policy on 05.04.2021. It was conceived that the revised State Water Policy based on state specific requirements and containing the provisions for flood management could be promulgated in 2021. Since certain provisions in the

	draft policy need more clarity in the wake of extreme environmental impacts caused by the climate change, the drafting Committee was directed to incorporate certain additional provisions and to submit the revised draft at the earliest. On 02.06.2022, Chief Engineer (I&A) and Chief Engineer (IDRB) have been directed to submit the revised draft of the State Water Policy by 31st July 2022.
Paragraph No. 2.2 Non - preparation of State Level Master Plans for water resources development and management The State Water Policy 2008 envisages the preparation of a State level Master Plan for water resources development and management. Also, it provides for the preparation of Master Plans for all the major rivers in the State. However, Master Plans for 42 out of 44 rivers are yet to be prepared though envisaged in the State Water Policy 2008. **Recommendation of C&AG** *'Government may ensure compliance with the provisions of the Kerala State Water Policy such as formulation of a*	**Constitution of State level River Basin Conservation and Management Authority (RBCMA)** Vide G.O (MS) No. 30/2020/WRD dated 15.04.2020, Government issued orders in principle for the constitution of a State level River Basin Conservation and Management Authority (RBCMA), which is primed for coordinating all water related activities at the river basin. A draft bill has already been prepared for the constitution of RBCMA. The bill was expected to be introduced in the Legislative Assembly in 2021 but lagged due to want of more clarity with regard to the powers and responsibilities of RBCMA. Meeting of the Drafting Committee will soon be convened and contentious matters will be sorted out so as to present the bill in the State Legislative Assembly at the earliest. **Formulation of State- level Master Plan for water resources development and management** It was envisaged in the State Water Policy 2008 that a State - level Master Plan for water resources development and management shall be prepared by compiling the status and action plans in each micro-watersheds, sub-basins

State level Master Plan for water resources development and management, formulation of Master Plans for the major rivers besides constituting a State Level Authority to coordinate all water related activities at the river basin level'.	and river basins in a hierarchical form. State Water Policy 2008 considered micro - watershed as the basic unit and the river basin as an integrated unit of micro-watersheds. Formulation of Master Plans for Municipal Corporations, Municipal Councils, Town Panchayats and Village Panchayats are progressing under the aegis of the Town and Country a Planning Department under the Local Self Government Department. Master Plans so prepared for local bodies under section 34 of the Kerala Town and Country Planning Act 2016 contain provisions for conservation of micro-watersheds and sub basins within the local area, regulations for natural hazard prone areas and disaster management. Harithakeralam Mission has also prepared plans for the rejuvenation of streams, ponds, lakes, etc. at the Gramapanchayat and Block Panchayat levels. **Formulation of Master Plans for major rivers in the State** Formulation of State level Master Plan for major rivers in the State is a combined effort of various stakeholder departments such as WRD, Revenue, Agriculture, LSGD etc. A holistic approach is required for the purpose and therefore, a task force comprising representatives from various stakeholder departments need to be constituted. Water Resources Department is focused on the preparation of master plans for major rivers in the State and priority will be given to those rivers that are prone to flood and passing through densely populated areas viz. Periyar, Chalakkudy, Pamba, Meenachil, Muvattupuzha, Karamana, Bharathapuzha and Chaliyar rivers. Preparatory

	works for formulating Master Plans for rivers have been started and Executive Engineers of Irrigation department have already been entrusted with collection of data of all the major rivers in the State in a time bound manner. On 02.06.2022, Chief Engineer (I&A) and Chief Engineer (IDRB) have been directed to submit an action plan for the phased formulation of Master Plans for the major rivers in the State.
Paragraph 2.3 **Non- enactment of legislation to identify and demarcate flood plains in the State** Government of Kerala has not enacted the Flood Plain Zoning Bill proposed by the Government of India in the year 1975. The need to prevent encroachments along rivers and flood plains was emphasised in the draft River Regulation Zone notification, 2016, under the Environment (Protection) Act, 1986 which was circulated to the States by the Ministry of Environment, Forests, and Climate change (MoEFCC). Identification and demarcation of the flood plains would	The State of Kerala had already informed the Ministry of Water Resources and Ganga Rejuvenation about the practical difficulties and limitations of enacting the Flood Plain zoning legislation in Kerala. The topography of Kerala was unique when compared with the states that had implemented the legislation. In India, only three States namely Manipur, Rajasthan and Uttarakhand had enacted the legislation as of December 2016. Kerala had never been considered as a major flood prone State till the flood of 2018 unlike the States located in Indo-gangetic plain. The States located on the banks of Ganges, Yamuna and Brahmaputra basins are yet to enact the Flood Plain Zoning Bill. Flood plain zoning needed institutional support and inter-departmental coordination. Though Kerala had an undulating topography and a high population density, Government recognises it is a vital tool in preventing flood. Feasibility study on enacting the Flood Plain Zoning Bill in the State will be conducted with the cooperation of various stakeholder departments.

enable the Government to take proactive measures in controlling potential encroachment activities in the flood plains and help the GoK in their activities on flood control. **Recommendation of C&AG** *'GoK may initiate action for a legislation/regulation on flood plain zoning, as well as constitute an Authority to identify and demarcate flood plain zones of the State and to prohibit or restrict the use of these lands'.*	
Paragraph No. 3.1 **Adequacy of rain gauges in Periyar basin** Periyar basin, which is having an area of 5159.71 sq. Km, is largely characterised as a hilly terrain upto Neeleswaram. As per the Bureau of Indian Standards (code IS: 4987-1994), rain gauge density at hilly areas with heavy rainfall	At the time of conducting audit, Irrigation department was maintaining ten meteorological stations with rain gauges in Periyar basin. Therefore the comment that only six rain gauges were operational is not true. After the 2018 floods, Government of Kerala decided to develop a full-fledged inflow forecasting and flood early warning system with real time monitoring operational in all river basins through Tipping Bucket Rain Gauges, Radar Level Sensors and Automatic Weather Stations. Out of the 99 Tipping Bucket Rain Gauges (TBRG) proposed to be installed in the river basins of Kerala under National Hydrology Project, 18 TBRGs were earmarked for Periyar

is 1 rain gauge per 150 sq. km. Accordingly, a minimum requirement of 32 rain gauges was to be made available in Periyar basin. Now, only 6 rain gauges conforming to IMD standards were in place. Though Irrigation Department and KSEBL are maintaining rain gauges in Periyar basin, data generated by those gauge stations conforming to IMD standards is utilized by IMD. Since data from Irrigation department gauges were not utilised by IMD, they are not being considered while assessing the adequacy of rain gauges in Periyar basin. **Recommendation of C&AG** *'Adequacy of the number of rain gauges capable of generating real time data in order to ensure accuracy of rainfall estimation may be ensured. System of sharing data from rain gauges with IMD*	basin. Proposed TBRGs have already been installed at various locations falls under the Periyar basin viz. Pattal, Thabore, North Paravoor, Vadattupara, Aluva and Neriyaangalam in Ernakulam District, Chinnar Estate, Vandiperiyar, Upputhura, Adimaly, Pallivasal, Kattappana, Vandanmedu, Nedumkandam and Kumily in Idukki District and Mathilakam in Thrissur District. Installed Tipping Bucket Rain Gauges (TBRG) have IMD specifications. Therefore, the data generated by TBRGs of Irrigation Department could be used by the IMD. Real time data generated from these rain gauges is available in the server maintained at the Integrated Command Control Centre (ICCC) at Jalavijnana Bhavan in Thiruvananthapuram. During the heavy rainfall in the months of October-November 2021, real time data from these stations have been supplied to the State Emergency Operations Centre (SEOC)/ District Emergency Operations Centre (DEOC) under Kerala State Disaster Management Authority (KSDMA) and it helped the KSDMA play an instrumental role in planning and coordinating emergency operations during this crisis period.

must be put in place at the earliest'.	
Paragraph No. 3.2 **Adequacy of flow gauge density in Periyar basin** Five flow gauges were installed in the Periyar basin by CWC and the Irrigation Department, of which three gauges at Kalady, Mangalapuzha and Marthandavarma are maintained by the Irrigation Department and the other two gauges at Neeleswaram and Vandiperiyar are maintained by the CWC. Even though, the existing number of flow gauges in the basin as a whole was adequate, there is a shortfall of one flow gauge in the free Periyar catchment, comprising of 2367.22 sq.km of hilly terrain (as per World Mateorological Organisation 2008 norms, one flow gauge per 1875 sq. km is needed in hilly terrain). An additional flow gauge needs to be located just upstream of Bhoothathankettu barrage,	In accordance with the World Meteorological Organisation 2008 norms, there is a requirement of three (3) inflow gauges for the 5159.71 sq. km Periyar basin (one flow gauge per 1875 sq. km). At present, there are 5 inflow gauges in Periyar basin and the audit admitted that the inflow gauge density is adequate as a whole. With respect to the audit observation that the free Periyar catchment, comprising of 2367.22 sq.km of hilly terrain needs an additional flow gauge to be located just upstream of Bhoothathankettu barrage, it is to be noted that the Irrigation department set up an additional four Radar Level Sensors (three under NHP and one under DRIP) in Periyar basin at 1) Malayattoor Kodanad bridge 2) Neriamangalam 3) Purappallikavu and 4) Bhoothathankettu. Real time data generated from these RLSs are available in the server maintained at the Integrated Command Control Centre (ICCC) at Jalavijnana Bhavan in Thiruvananthapuram.

which is a major control point in the periyar basin.	
Paragraph 3.3 **Flood forecasting stations not set up in the State** Central Water Commission requested (October 2011) Government of Kerala to provide list of reservoirs which required inflow forecasting stations and list of cities/towns for flood forecasting purpose. CWC confirmed (August 2019) to Audit that the State failed to furnish the details and hence no Flood Forecast Stations (FFS) were set up by the CWC in the State prior to flood of 2018. This was despite 275 flood forecasting stations having been set up by CWC across the country by the year 2017. The failure of GoK to provide list of reservoirs and cities/towns to CWC resulted in non-installation of FFS in the State and resultant deprival of data which State could have utilised for flood	Even though the list of reservoirs which requires inflow forecasting stations and list of cities/towns for flood forecasting purpose was not formally submitted to the Central Water Commission, a lot of discussions with regard to the efficacy of flood forecasting systems suitable for the State had been held with CWC. In the spirit of the discussions, the Government have had with the CWC, it was decided to install 8 Tipping Bucket Rain Gauges, 18 Radar Level Sensors and 19 Automatic Weather Stations in various river basins for the purpose of real time flood forecasting in 2014. The work was awarded to the contractor in April 2014 at a cost of Rs.1.34 crore. Most of these flood forecasting machineries were installed prior to the flood of 2018. Therefore, it is not true to say that the State of Kerala was not concerned over the setting up of flood forecasting stations in flood prone basins prior to the flood of 2018. Chief Engineer, Irrigation & Administration, on 17.04.2021 has formally forwarded the list of flood prone cities/ towns in the State that require flood forecasting stations and also the list of reservoirs, which need inflow forecasting. In light of the calamitous 2018 floods, Government of Kerala had strengthened the inflow forecasting and flood early warning system in the

forecasting purpose.	State by setting up more Tipping Bucket Rain Gauges, Radar Level Sensors and Automatic Weather Stations. The work for installing the devices was awarded to the contractor at a cost of Rs. 10, 92,96,320/- on 27.01.2020. Out of a total of 168 flood early warning systems purchased already, 97 Tipping Bucket Rain Gauges, 46 Radar Level Sensors and 12 Automatic Weather Stations were installed. Remaining 13 equipments will soon be installed.
Paragraph 3.4 **Non- completion of a project intended for obtaining data required for flood management** Irrigation department awarded the work for installing a Real Time Data Acquisition System to M/s Astra Microwave Products Ltd. Hyderabad in April 2014 at a cost of Rs. 1.34 crore. Many of the equipment installed by the firm are not functional. Though more than five years have elapsed, the objective of obtaining real time hydrological data useful for improving flood management capabilities remained unachieved.	In the year 2014, Government of Kerala decided to set up a real time flood forecasting system by installing 8 Tipping Bucket Rain Gauges, 18 Ra1dar Level Sensors and 19 Automatic Weather Stations in various river basins. The work was awarded to the contractor, M/s Astra Microwave Products Ltd on 26th April 2014 at a cost of 1,37,97,337/-. The contractor was bound to complete the installation of the system by 25.07.2014. Since data generated from some of these devices were found to be erroneous and the firm failed to fulfil their obligations to rectify the defects within the time limit or the extended period, action has been initiated against M/s Astra Microwave Products Ltd. for breach of the agreement conditions. Accordingly, Superintending Engineer, Field Studies Circle, Thrissur (agreement authority) terminated the contract of the firm vide proceedings dated 28.12.2021. On 30.12.2021, the agreement authority directed the Contractor to pay an amount of Rs. 62,04,749/- within three months, towards tentative liability as per relevant clause of Kerala PWD manual.

Paragraph No. 3.7 **Siltation of dams and reduction in storage capacity** Siltation study was conducted in all the reservoirs under the control of WRD. Though sanction was accorded in September 2017 by GOK for de-siltation of Mangalam and Chuliyar dams, the works are yet to commence as of November 2019. **Recommendation of C&AG** *'In view of the possible loss of active storage volume of dams through sedimentation and its consequential adverse impact on flood control, KSEB and Irrigation Department may ensure that sedimentation studies as prescribed in Reservoir Operation Guidelines issued by Bureau of Indian Standards are conducted and timely action taken to arrest the capacity loss of reservoirs'.*	Status of desiltation of dams under Water Resources Department Mangalam dam Desiltation of Mangalam dam is a three yearlong project and was started on 17.12.2020. As of 19.04.2022, 133673 CUM sediments (5%) removed out of a total estimated quantity of 2.95 MCM. Malankara dam KERI, Peechi conducted a bathymetric survey in 2020-21 in connection with the distillation of Malankara Dam. Steps are being taken by the Chief Engineer, Irrigation and Administration to invite expression of interest for preparation of a detailed project report for removal of soil and silt from Malankara Dam. Malampuzha dam As per the decision dated 04-12-2020 of the 9th High Level Empowered Committee on desiltation, the Government has given permission to call for expression of interest (EOI) for the desiltation of Malampuzha Dam. Karappuzha dam According to a bathymetric survey conducted by KERI, Peechi in February 2021, the storage capacity of the Karappuzha Reservoir was found to be decreased by 12.56%. Steps are being taken for inviting EOI. Kanjirappuzha dam According to a bathymetric survey conducted by the Kerala Engineering Research Institute in 2020, the storage capacity of the Kanjirapuzha dam was

	found to be reduced from 68.533 MM3 to 51.609 MM3. Steps are being taken for inviting EOI. Chulliyar dam Government vide G.O (Rt) No. 21/2021/WRD dated 07.01.2021 have accorded sanction for awarding desilation work of Chulliyar dam to Kerala Irrigation Infrastructure Development Corporation (KIIDC) on turn-key basis. Walayar and Meenkara dams Vide G.O (Rt) No. 22/2021/WRD dated 07.01.2021, desiltation work of Walayar and Meenkara dams was awarded to Kerala State Mineral Development Corporation Ltd. (KEMDEL) on turnkey basis. Aruvikkara dam As per G.O (Ms) No. 1/2020/WRD dated 06.01.2020, administrative sanction was accorded for the desiltation of Aruvikkara dam and the Kerala Water Authoiry was authorised to invite Expression of Interest (EoI). The work of desiltation will be started without delay upon awarding the work to a qualified bidder. State of Kerala has now launched a project named as Operation Vahini to clean and deepen all the major rivers and its tributaries, streams and canals by removing silt and the objects that hinders the smooth flow of water to prevent flood events in future. The project is going ahead successfully.
Paragraph No. 4.4 **Obstruction of flood discharge through Thottappally spillway**	Length of the leading channel of the Thottappally spillway right from the spillway to the sea mouth is 800m and it has a width of 380m. Due to the accumulation of mineral sand in the downstream of the spillway and the

Flood discharge through the TSW was considerably reduced due to the accumulation of mineral sand and due to the trees planted inside the mouth of the estuary. **Recommendation of C&AG** *'Government may, prioritise works such as deepening of the leading channel upstream of TSW and timely breaking of developing sand bar, if any, at the sea mouth so as to ensure unhindered flow of flood waters to the sea, giving due consideration to extant environment related instructions while so doing'.*	trees planted inside the sea mouth by the Social Forestry Department, width had been reduced from 380m to 150m. **Status of removal of trees at sea mouth** Since it was observed that the trees planted inside the estuary were impeding the flow of floodwaters through the spillway, the State Government have decided to remove the entire trees planted inside the estuary. Accordingly, trees as a whole, which were planted within the 380m width of the downstream were cut down by the district administration, Alappuzha on 22nd May 2020. As part of the mission, 550 casuarina trees, which were numbered in the year 2018 and reckoned to be obstructing the flow of floodwaters were removed. As a result width was extended to a further 230m thereby reaching the required width of 380m. **Status of removal of mineral sand from downstream of the spillway** With a view to deepen and widen the estuary, Irrigation Department started removal of mineral sand from pozhi mouth and downstream of the spillway on 20.05.2020. Accordingly, an estimated quantity of 242831 cub.m sand was dredged; out of which a quantity of 175319 cub.m sand was transported to KMML. Dredging works came to a close on 22.07.2020. Through the two month long dredging mission, spillway channel was deepened and width was widened to 380m. Within a few months after completing the dredging, a sand bar was formed occupying a width of 75 m at the pozhy mouth. Accumulation of sand at the

	pozhi mouth is rampant. In 2021 also, dredging of sand was carried out in the downstream. An estimated quantity of around 2,49,000 cu. m. sand was dredged out and the exercise was completed on 27.08.2021. Government had prioritised the work of breaking down the sand bar at the pozhy mouth and is being carried out timely and periodically. There is an erratic observation in the audit report that the width of the leading channel of the TSW in the upstream side of the spillway from Thottappally to Veeyapuram is only 80 m against the required width of 365 m. The leading channel of the TSW has a length of 11 km from Thottappally to Veeyapuram. In the upstream side of the spillway, there is no such directive to maintain a width of 365 m along the 11 km stretch. In the upstream it has a variable width averaging to 100 m. The banks on both sides are heavily populated. Any change in width requires the people living on the banks to be rehabilitated. With regard to the downstream of the spillway, which has a length of 800 m, it has been prescribed to maintain a width of 380 m. The prescribed width has been maintained by the Irrigation department by cutting the trees planted inside the estuary and by removing the mineral sand. A new service/scheme was started in 2022-23 financial year for ensuring the smooth flow of flood waters from Manimala, Achenkovil and Pamba rivers by deepening the 11 Km stretch of the leading channel of Thottappally spillway. Funds provided for this scheme during the current financial year (2022-23)

	was 5 crore. Presently, works for dredging the upstream portion of the spillway is ongoing and 16.5% of works has been completed as on 31.03.2022. Besides, Government as per G.O (Rt) No. 360/2021/WRD dated 09.07.2021 have accorded administrative sanction for protecting either banks of the leading channel at an estimated cost of Rs.70.3 crore.
Paragraph No. 5.2 **Execution of immediate restoration activities in post flood scenario** WRD was sanctioned Rs.536.27 crore in 2019 for immediate repair and restoration of damaged infrastructure during 2018 flood. As of January 2020, only 20% of the works was seen completed. **Recommendation of C&AG** *'Government may put in place a system of periodic monitoring of status of works of immediate nature funded by SDRF to ensure that works sanctioned are completed on priority basis, given the State's increasing vulnerability to severe flooding events'.*	Funds to the tune of Rs. 536.27 crore have been provided to the Irrigation Department from SDRF for the immediate repair and restoration of damaged infrastructure during 2018 flood. As of 18.03.2022, agreements have been executed for 97.94% of works and 91.09 % of works have already been completed.

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Public Accounts Committee (2021-23)-Action Taken report on C&AG report No.6 of the year 2021.

Sl. No.	Para No.	Recommendations	Action Taken
1	Para 2.5 Implementation of Civil Defence in the State	The State may initiate action to operationalise the Civil Defence Training Institute for the fulfilment of the intended objective of training and equipping sufficient number of Civil Defence volunteers. Civil Defence needs to be strengthened in the State through ensuring a) adequacy of communication facilities and trained volunteers including availability of licensed HAM radio operators, and b)availability of emergency responder kits to enable timely and effective rescue operation during emergency/disaster situations.	The Civil Defence System formed under the Kerala Fire & Rescue Services as per G.O. (Ms)No.132/19/Home dated 31/08/2019, started functioning from December 2019. Online applications are invited from the public who are willing to work with the fire service as volunteers. A total of 6200 Civil Defence Volunteers were recruited across the state and recruited 50 trained volunteers at each fire station. A 15-day curriculum has been prepared to impart station-level, district-level, and state- level training to the selected civil defence volunteers. It was decided to conduct the state level trainings at the Civil Defence Academy, but as around 100 personnel, vehicles, and equipment of NDRF are camping in the said building. The civil defence volunteers are currently being given state level training using the limited facilities of the Kerala Fire & Rescue Services Academy. About 3,600 Civil defence volunteers have been trained in disaster relief and disaster preparedness operations under these limited circumstances. The training of 3679 volunteers selected in the second phase was also started. Civil defence is functioning under the department with an aim to train at least 1% of

the state's population in disaster management and rescue operations. Handing over the Civil Defence Academy entirely to the Department will enable to conduct the training more efficiently.

State-level residential training for Civil defence volunteers is scheduled to be conducted at the Civil Defence Academy.

Para 2.5.2) Mainstreaming Civil Defence in Disaster Risk Reduction

An amount of Rs.225.52 lakh had been sanctioned for the financial year 2014-15 under the scheme Mainstreaming Civil defence in Disaster Risk Reduction related to the empowerment of civil defence. Since the civil defence system was not established in the state at that time, the said amount was not released to the Fire & Rescue Services Department. As per G.O(Rt)No.2332/ 2021/Home dated 31.08.2021 administrative sanction was issued for procuring equipments /vehicles for Civil defence, utilising the amount.

Para 2.5.3) Slow pace of implementation of Aapta Mitra Scheme

Training has been given to 200 Nos. of Apata mitra volunteers selected by KSDMA from Kottayam district at Fire & Rescue Services Academy, Viyur, in the first phase.

In the second phase to upgrade Aapta Mitra, it has been decided to provide Aapta Mitra

			training to volunteers from the other 13 districts. As requested by KSDMA the details of 3679 Civil Defence Volunteers have been provided to them for imparting emergency training .
2	**Para 2.6** Revamping of Kerala Fire and Rescue Services Academy	Priority needs to be given to review the adequacy of equipment, vehicles and infrastructural facilities in the Fire and Rescue Services Academy as well as in Fire and Rescue stations so that the GoK's dedicated force for rescue services may be adequately equipped to handle any flood or other disaster situation.	As per G.O.(Rt)3765/2016/DMD dated 22/09/2016 Government had accorded administrative sanction for an amount of Rs.98.25 lakh for the renovation of Kerala Fire and Rescue Services Academy at Viyyur . Out of this closed circuit television surveillance system has been completed for an amount of 2.50 lakh rupees. Rs.18,12,163/- was available for the construction of the conference hall. Construction work has been completed accordingly. But the remaining part of the construction work as per the proposal is yet to be completed. Steps are being taken to prepare estimate and plan for constructing Hi-tech classrooms (2 nos.), Modern library system, Health club facility, Centre of Chemical Disaster Response Training Yard with PPE and Chemical laboratory systems.
3	**Para 2.7** Non-functioning of Virtual Cadre for Disaster Management	Virtual Cadre needs to be formalised and strengthened in the State so that the disaster-specificnodal departments could work in tandem with the State/ District Emergency Operations Centres through the cadre, for ensuring coordinated response to disastrous events	As per Section 16 of the Disaster Management Act 2005, steps are being taken to form the Virtual Cadre Force.

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Public Accounts Committee (2021-23)-Action Taken Report on Para No. 2.5.1 of C&AG Report No.6 of the year 2021

Sl. No	Audit Para	Recommendations	Action Taken
1.	**Para 2.5.1** **Unfruitful expenditure of 1.54 crore on construction of Civil Defence Training Institute.**	The State may initiate action to operationalise the Civil Defence Training Institute for the fulfilment of the intended objective of training and equipping sufficient number of Civil Defence volunteers. Civil Defence needs to be strengthened in the State through ensuring a) adequacy of communication facilities and trained volunteers including availability of licensed HAM radio operators, and b) availability of emergency responder kits to enable timely and effective rescue operation during emergency/ disaster situations.	Civil Defence was officially formed in the State under Fire and Rescue Department on August 2019 and the Civil Defence Academy has also started functioning during the same period. Even though the Civil Defence Academy Viyyur was handed over to Fire and Rescue Department on April 2018, it is still being used for the accommodation of the NDRF team members and could not be utilized for Civil Defence training and therefore, the Civil Defence Academy is functioning in the Hostel Block of Fire and Rescue Academy, Viyyur for the last 4 years. No training facilities -classroom, accommodation facilities, mess, toilet facilities etc. are

			available at the CDTI Viyyur for Civil Defence training as it is entirely occupied for the accommodation of the NDRF team (except a small office room). There are 6450 Civil Defence Volunteers (50 volunteers x 129 Fire and Rescue Station) in the state and the recruitment of another 3200 volunteers is ongoing. The strength of Civil Defence Volunteers in the state will thus become 9650 and the state level training (3 days) of these volunteers has to be conducted at the Civil Defence Academy. Now the state level training is being conducted by utilizing the facilities – classroom, training ground, hostel etc. of Fire and Rescue Services Academy. Since there are a variety of Basic and in-service training courses being conducted at the Fire and Rescue Services Academy, their

			training facilities and accommodation facilities could not be allotted for the Civil Defence training. Also, Fire & Rescue Services Department will be starting refresher courses for the Civil Defence Volunteers who have already completed the training and four refresher courses on various subjects are scheduled to be conducted in the coming months. The Department must impart training to the Civil Defence Volunteers all over Kerala and do not have the accommodation facilities for conducting the residential training. Lack of accommodation and other infrastructure facilities in Civil Defence Academy have adversely affected the Civil Defence training in the State. As of now, there is no land or building available with Fire and Rescue Department for Civil Defence training in

			the State. Even though the CDTI, Viyyur was handed over to Fire and Rescue Department on April 2018 the ownership of entire land (8 acres) remains with the Revenue Department itself. Therefore, even though funds are being allotted to Fire & Rescue Services Department for construction of CDTI building it could not be utilized. The Director General, Fire and Rescue Services Department had submitted a proposal for allotting 4.63 acres of land at the compound of Civil Defence Academy, Viyyur, Ramavarmapuram for constructing building for CDTI. The same is now under the consideration of the Revenue Department.

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Remedial Measures Taken Statement

Performance Audit on Preparedness and Response to Floods in Kerala

Report No. 6 of 2021

Para	Recommendation	Action Taken
2.3	Non-enactment of legislation to identify and demarcate Flood Plains in the State - Government of Kerala may initiate action for a legislation/regulation on flood plain zoning, as well as constitute an Authority to identify and demarcate flood plain zones of the State and to prohibit or restrict the use of these lands.	The matter of delineating and demarcating flood plains being related to Water Resources, based on Ltr. No. 33-02/2020-NDM-I dated 14-1-2022 from Ministry of Home Affairs, Govt. of India, a request has been sent to the Department of Irrigation, Government of Kerala to consider the recommendation for 'delineation and demarcation of flood plain zones on certain notified stretch(es) of rivers(s) within the State and regulation of various activities permissible therein'. The Permanent Expert Technical Committee for Hydraulic and Hydrological Studies chaired by Principal Secretary (Ex-officio), Dept. of Science and Technology, Govt. of Kerala and convened by Chief Engineer, IDRB examined the matter in 14-3-2023 and have decided to conduct a detailed technical conclave to examine the matter in detail. Mapping of flood plains are part of land use zone mapping and is not a function of Disaster Management Authorities under any provisions of Disaster Management Act, 2005. KSDMA has mapped flood probable zones and have published the results for historical 1 in 10 year to 1 in 500 year scenarios and in the worst case climate change scenario of RCP 8.5, in public domain. The document and the maps have been shared with local government department and via Orange Book to all departments on May 2022.
		The following rule positions are clear in this regard and this view of the State Government is also upheld in the judgement of WP(C) No. 33405 of 2018 dated 28-2-2022 by Hon'ble High Court (Division Bench). The final paragraphs of

2.4	Flood Hazard Map not conforming to criteria - Government of Kerala may take steps to ensure availability of large scale flood hazard maps conforming to CWC criteria which would facilitate planning, policy making and prioritisation of flood mitigation activities by identifying flood risk areas.	the orders are reproduced here 'Perusal of the same shows that several factors are being considered for the scientific assessment of flood prone areas in the State and court cannot fix any outer limit for the completion of this work. Almost all the reliefs have been addressed by the respondents (*Government of Kerala, Water Resources Department, IMD, CWC, KSEB, NDMA, KSDMA, C & AG, Govt. of India*). In view of the above, the writ petition is disposed of directing the respondents to take all possible remedial measures and regularly monitor the same without any failure'. In the meantime, KSDMA in collaboration with UNEP, UNGRID and CIMA Italy has prepared flood hazard probability maps for entire Kerala and is published in the website of KSDMA https://sdma.kerala.gov.in/hazard-maps/. These maps are prepared in 90 m by 90 m spatial resolution. Thus, while the notified central agency is yet to deliver, KSDMA took initiatives to use available information in the best possible manner and has utilised flood maps prepared by NCESS from 2016 and now prepared refined hazard susceptibility maps jointly prepared by KSDMA-UNEP-UNGRID-CIMA
		With a view to gainfully utilise the asset a conscious decision was taken (May 2016) to provide the building for housing National Disaster Response Force (NDRF) which is a valuable response arm of the Government. Another portion of the building was allocated for the functioning of the office of Civil Defence Institute. This strategic decision was made in consultation with all departments including Fire & Rescue Services to facilitate prompt response to Disasters in the State. This decision had also avoided wasteful

		expenditure which would otherwise have entailed for accommodating NDRF. Such temporary pre-positioning of the NDRF Team in the building along with CDI during the monsoon season also facilitated utilisation of their services for undertaking civil defence training in the State.
2.5.3	Slow pace of implementation of Aapda Mitra Scheme- The State may initiate action to operationalise the Civil Defence Training Institute for the fulfilment of the intended objective of training and equipping sufficient number of Civil Defence volunteers. Civil Defence needs to be strengthened in the State through ensuring a) adequacy of communication facilities and trained volunteers including availability of licensed HAM radio operators, and b) availability of emergency responder kits to enable timely and effective rescue operation during emergency/ disaster situations.	It may also be noted that Civil Defence became fully operational in the State only in 2019 (GO (Ms) No. 132/2019/Home dated 30-8-2019) and now all districts of Kerala are notified Civil Defence Districts with 10000 Volunteers. Thus, through judicious decision for utilisation of an otherwise idled building in 2016, the Government could avoid wasteful expenditure. The NDRF provided gainful capacity building trainings in the State and thereby increased civil defence ability. Further, it may be noted that this has not hampered the constitution and functioning of Civil Defence in the State. The State as on April 2022 have more than 10000 operational trained Civil Defence Volunteers under the Fire and Rescue Services. However, efforts are ongoing to persuade NDRF to establish their own Regional Response Centre in Kochi at the earliest and move out of the CDTI.
2.6	Revamping of Kerala Fire and Rescue Services Academy - Priority needs to be given to review the adequacy of equipment, vehicles and infrastructural facilities in the Fire and Rescue Services Academy as well as in Fire and Rescue stations so that the GoK's dedicated force for rescue services may be adequately equipped to [illegible]	The Department is provided with additional fund allocations from State Disaster Response Fund based on request from Home Department. A recent example of providing funds to Fire and Rescue Services from SDRF may be found in GO (Rt) No. 850/2022/DMD dated 3-12-2022, GO (Rt) No. 794/2022/DMD dated 29-10-2022 and GO (Rt) No. 199/2023/DMD dated 28-03-2023. Funds were also provided through Aapda Mitra scheme for arranging necessary facilities in Fire and Rescue Academy and Water Safety Academy to train volunteers. Thus, over

	any flood or other disaster situation.	and above the funds made available directly by the Government, funds are made available by SDMA to Fire and Rescue Services after adequate evaluation of need.
		Deployment and maintenance of communication and alternate communication infrastructure in dam sites is not the responsibility of KSDMA as per the extant norms in 2018. This is a specific responsibility assigned to the Dam Owners (in Kerala dam owners are KSEB, Irrigation and KWA) by Central Water Commission [Guidelines for Developing Emergency Action Plans for Dams Doc. No. CDSO_GUD_DS_01_v2.0, February 2016]. Thus, a specific authority for this purpose is notified by CWC, the national nodal agency under Disaster Management Act, 2005 for management of floods. As of 2019, the Government of India has formed National Committee on Dam Safety and State Dam Safety Organisation under the Dam Safety Act, 2019 (Central act 41 of 2021). It is known to KSDMA that KSEB and Irrigation Department has provided Satellite Phones in dam sites as an alternate communication means. The recommendation that KSDMA should ensure fail proof connectivity to all government offices is not, pragmatic. Government is in the process of integrating Government offices with at least one communication network such as K-Phone which is ubiquitously available for civilian communication. 92 Emergency Operations Centres in the State are networked through 2 wired and 2 wireless communication systems. [illegible] fail proof communicati[illegible]

		possible only based on near earth satellites, which functions in narrow bandwidths such as Starlink of M/S SpaceEx, Kuiper of M/S Amazon, OneWeb and Telesat. Even these are subjected to failures based on dependencies such as batteries, systemic failures and solar flares. None of these are currently offering any service in India. The communication infrastructure like GSM, telephonic, internet communication etc. were temporarily disrupted in several areas during or subsequent to the 2018 floods due to power failure and optical fibre disconnection etc. This is not a case only in Kerala, but is a case across the world. There are no global examples to show case that communication systems worked in an uninterrupted manner in an area that was affected by a 1 in 500-year rainfall return probability flood. Currently, the national system of 112 is the primary network for emergency reporting and coordination which also works on existing BSNL backbone and thus is also not 100% failure proof.
3.5.2	Maintenance of Communication Infrastructure - KSDMA may ensure that fail-safe communication infrastructure is available in vital installations such as at dam sites and that a built-in redundancy of different layers of communication capable of functioning during the most adverse circumstances exists in flood-prone locations across the State.	The remark of Audit to continue maintaining VHF is not acceptable as these are analogue systems of the past and KSDMA cannot invest in old systems with numerous failure points and dependencies. The one and only VHF network that is to be maintained in the best interest of the State is that of Police which also is moving on the Digital Radios. As recently as in March 2021, Government of India itself is trying to focus on satellite phones and satellite based PolNet2 for disaster communication. The International Telecommunications Union, the regulator of Telecommunications Standards, in their recommendation ITU-R M.1854-1 states the following "that mobile-satellite terminals and ancillary equipment may be ubiquitously deployed and at times may represent the only viable solution to provide emergency telecommunication

services for relief operations". The ITU Handbook on Mobile-satellite service (MSS) states that "To overcome the disadvantages associated with HF and VHF radio communications, the International Civil Aviation Organization (ICAO), a specialist agency of the United Nations, encouraged the development of satellite-based communications". This is the path that KSDMA is resorting to facilitate satellite based communication systems to critical emergency coordination offices.

The critical response coordination offices of Kerala being the District Emergency Operations Centres and State Emergency Operations Centre has 6 to 7 layers of communication systems including Internet, GSM, Land phone, Hotlines, ISAT and Police Wireless. At Idukki, Ernakulam, Wayanad DEOCs and State EOC there is also NDMS VSAT connectivity. State has also supplied 14 Digital Radios with Antenna, GPS and Programming Kits and 4 generators to Fire and Rescue Services. 4 SBMDVTs are also under procurement. There is thus a healthy mix of civilian and official communication systems with the most current technology that's accessible to civil administration. By increasing the number of media of communication, the possibility of communication failure is reduced significantly; When one system fails, yet another system will be used. None of the above systems are always-on systems.

The general causes of disruption are physical destruction of network components, disruption in supporting network infrastructure, network congestion, etc. For example, when a mobile tower is affected, the connectivity may get disrupted during which the land phones or hotlines or satellite phones may come in handy.

Cellular on Wheels (COWs) are also deployed for much needed connectivity in times of emergencies in order to add on to

communication redundancy. Thus, all solutions accessible and affordable are made available to emergency coordinators.

The NDMS project involved the supply of 4 ISAT phone, 4 VSAT terminals and support of 4 field engineers by NDMA through BSNL.

As the NDMS systems were not handed over to the State/Districts and the project was not completed, the Additional Chief Secretary, Disaster Management requested (9-5-2018) NDMA to consider extending the term of service of the Field Engineers for 6 months from June 2018 onwards. Further, the State also requested to extend the project to all districts and to provide clarification regarding the AMC. Thus, the SEOC took pre-emptive action prior to floods to ensure the continuity of services of NDMS.

It may be noted that in August 2018, the VSAT system or any of its components were not officially handed over to the State or Districts for operational maintenance. The matter that the VSAT system at SEOC needs to be shifted to the new premises and rectification of faults of the VSAT system of Idukki, Wayanad and Ernakulam was taken up with NDMA as no resolution was forthcoming from BSNL. As mentioned earlier, the ISAT Phones were a part of the deliverables of the NDMS project. The ISAT Phones (4 numbers) were delivered (17-8-2018) and were issued to DEOC Ernakulam, Idukki and Wayanad despite flood conditions in these districts. Thus, it is evident that the NDMS project was not completed and handed over to the State and Districts during the time of floods and the ISAT Phones which were an integral part of the project was delivered on 17-8-2018.

From the letter of NDMA to BSNL, it is evident that SEOC did all in its capacity to continuously follow up and escalate the

		matter to the NDMA for necessary intervention. Hence the argument that 'it took SEOC more than one year to get system repaired' is unfounded.
5.2.1	National Disaster Management Services	The NDMS is also a system with multiple dependencies and hence there is possibility that the system may fail on a given day but the communication requirement shall be met by another system available with SEOC/DEOC. The SEOC in writing requested BSNL vide SEOC/Proj/207/2016 dated 4-7-2018 that support should be provided to relocate the VSAT terminal to the new building. A reminder seeking urgent action was sent on 17-10-2018 and 18-1-2019 and 17-5-2019. NDMA requested BSNL to render necessary service as on 18-1-2019. A response was received on 17-5-2019 from BSNL informing the cost of relocation. Vide SEOC/Proj/207/2016 dated 13-7-2019 and 13-8-2019, SEOC agreed to make the payment. As no response was forthcoming, vide SEOC/Proj/207/2016 dated 3-10-2019, the matter was informed to NDMA. NDMA vide Letter F. No. 18/01/2017Kerala/NDMS dated 10-10-2019 also directed BSNL to do the needful to shift the VSAT terminal to the new building of SDMA. After such constant follow up, the BSNL relocated the instrument to the new building on 15-10-2019. Thus, it is evident that SEOC did everything in its capacity to promptly operationalize the VSAT terminal even before the entire office was shifted to the new building of SDMA. However, adequate help was not forthcoming from the concerned technical agency and the matter was also reported to NDMA promptly. Since several other communication systems were available for use during the period as indicated above, it is not correct to observe that there was no failsafe communication network.

		KSDMA was aware of the fact that ISAT Phones will not work indoors but it is not true that ISAT phones do not work during overcast conditions. As it is with any satellite signals (including DTH television), there is reflectivity interference and hence during cloudy conditions and high solar insolation the reception and return signals are affected temporarily and thereby the quality of voice and the bandwidth of transmission may be affected. This depends on the location from which the phone is used.
		The National Disaster Management Plan 2019 prepared under Section 11 of the DM Act, 2005 clearly lays down the responsibilities of National and State Organisations in Earthquake Monitoring and establishing real time monitoring networks. The responsibility of DMD, SDMA, DDMA and RD is 'Share information widely'. Establishing such a network is therefore not a statutory responsibility of State Government, but is the responsibility of Ministry of Earth Sciences, Ministry of Electronics and Information Technology and National Level Research and Technology Institutions. Thus, the statutory responsibility to establish such instruments depending on need is upon Ministry of Earth Sciences, Ministry of Electronics and Information Technology and National Level Research and Technology Institutions including NGRI in consultation with National Centre for Seismology. From the available information in the website of NCS, there is already sufficient earthquake monitoring instrumentation for disaster related information dissemination in the country and the State. The responsibility to consider increasing or decreasing such an instrumentation is that of the Ministry of Earth Sciences, Ministry of Electronics and Information Technology and National Level Research and Technology Institutions including NGRI in consultation with National Centre for Seismology.

		With the enactment of the Dam Safety Act, 2021, there is a specific statutory direction and responsibility on dam owners for establishing such a system under Section 34 (1) & (2) of the Dam Safety Act, 2021
3.5.3	Non-functional state-of-the-art Digital Seismographs - Keeping in view the role of the seismograph network in Idukki in studying seismic behaviour and their linkage to the safety of dams in the region, Government of Kerala may ensure that the network of seismographs as recommended by NGRI is put in place at the earliest and the agencies concerned receive real time seismic data from these locations.	34. (1) In the case of every specified dam, having a height of thirty metres or above or falling under such seismic zone, as may be specified by the regulations, the owner of the specified dam shall establish a seismological station in the vicinity of each such dam for recording micro and strong motion earthquakes and such other data as may be specified by the regulations. (2) Every owner of a specified dam shall collect, compile, process and store data referred to in sub-section (1) at such suitable location and in such manner as may be specified by the regulations. KSEB has informed that they have initiated procurement for establishing seismic equipment and data acquisition systems in the observatories by adopting state of the art technologies, vide email dated 23-3-2023 from Chief Engineer, Dam Safety & DRIP (cedamsafety@gmail.com). Vide Ltr. No. PL1(A) Mon/36806/2017 dated 2-7-2022, the Chief Engineer, Irrigation Department has informed that they are establishing seismic monitoring instruments in 9 out of the 16 dams/barrages that are under the said dam owner. Further, the spare seismograph was meant specifically as a Spare and not as a routine deployment equipment. By the time the procurement and training were completed, KSDMA had begun construction of its new building and the authority moved to its new building in a busier road, in the city. The location is not appropriate for establishing

		seismographs as local heavy traffic in the road will impose noise on such highly sensitive instruments. Therefore, the instruments have been handed over to KSEB on 3-8-2020 based on their request for a Spare.
		Kerala has witnessed rapid urbanization in the last two decades and almost half (47.1%) of its population resides in urban areas. The population of the state has increased from 31.8 million in 2001 to 33.8 million in 2011 with a growth rate of 4.91%. According to the Census of 2011, the urban population in eight out of fourteen districts in the state have increased by more than 40% and the share of urban area in ten districts have more than doubled within a decade. The number of urban settlements within the territory of Kerala has increased from 21 in 1901 to 520 in the Census of 2011 and this trend is expected to continue in the coming years. This includes six municipal corporations and eighty-seven municipalities with self-governing authority. Thus, population pressure and needs are determining the conversion of land use/land cover. The State Disaster Management Plan 2016 clearly identified land use change as a critical factor increasing the disaster vulnerability of Kerala. Enactment of a new integrated, risk sensitive and terrain specific land use legislation is highlighted in the Rebuild Kerala Development Plan. This is the only means of reducing disaster vulnerabilities of the State. While Audit examines land use/land cover change in the State it may also acknowledge that the State Disaster Management Authority through State Disaster Management Plan not only identified, but also succeeded in ensuring risk sensitive land use restrictions in the State such as the following:

		a. No permission for blasting type quarrying in the high hazard zones of Kerala (Upheld in WP (C) No. 4022 of 2017 dated 16-11-2018) b. Restriction in construction types in Wayanad district owing to hazard proneness based on the advice of KSDMA (Upheld in WP(C) No. 24873 of 2015 (H) dated 3-11-2015) c. Limiting extraction of ground water to 25% of the permitted amount in light of drought (Upheld in WP (C) No. 2986/2017 (W) dated 11-04-2017) d. Prevention of obstruction of streams and natural drains - based on the direction of KSDMA, the Government amended the Kerala Municipal/Panchayath building rules in S.R.O. No. 828/2019 dated 8-11-2019 and included Section 22 (4) "No construction shall be made to obstruct the natural drains and streams in a plot. Failure to comply with this instruction will invite penalization under Section 51 of the Disaster Management Act, 2005 (Central Act, 53 of 2005)". e. Report of the Technical Committee for suggesting amendments to the techno-legal regime (https://sdma.kerala.gov.in/wp-content/uploads/2019/10/14-FINAL-RECOMMENDATIONS-TLR-IN-DM.pdf) - The report was issued to Local Self Government Department to amend the Kerala Municipal & Panchayath Building Rules by the State Executive Committee of KSDMA Thus, KSDMA not only identified land use as a major determinant factor of vulnerability in the State, but also
4.1	Result of LULC study in the Periyar basin - In view of the drastic change in land use over the past few decades with its impact on the recent floods, Government may initiate urgent steps to review the adequacy of the measures initiated to reduce the risk of vulnerability to floods, attributable to changes in land use. Government may also initiate steps for an integrated and comprehensive legislation and a land use policy after reviewing the existing land management related Acts/rules/regulations/policies etc. to reduce disaster vulnerabilities, as highlighted in the Rebuild Kerala Development Programme.	

31 RMT (Power Department-I)

STATEMENT OF ACTION TAKEN ON THE REMARKS CONTAINED IN REPORT No.6 OF THE YEAR 2021 OF COMPTROLLER AND AUDITOR GENERAL OF INDIA RELATING TO PREPAREDNESS AND RESPONSE TO FLOODS IN KERALA

Introduction

At the outset, it is important to note that the entire State of Kerala had experienced unprecedented and torrential rainfall in the month of August 2018, which assumed the proportion of a severe natural disaster tantamount to a similar calamity occurred 94 years back in 1924. This storm of 15-17, August 2018 was spread over the entire land mass of Kerala State with its eye centered at Peermade, where more than 800 mm rainfall recorded. Such an extreme event was handled by the State Government as well as KSEBL as a crisis management on a real time basis.

The quantum of rainfall experienced in the Periyar basin during a short period of 3 days from 15th to 17th August, 2018, if we distribute over the entire Periyar river basin would amount to 584 mm, which represented 32% of the average rainfall received during the four months of the South-West Monsoon, which in turn rendered all the flood control operational machinery out of gear. The catastrophe brought in its wake large scale floods and destruction of property besides loss of life.

The crisis management of Dam Safety and reservoir operations during the catastrophic flood period was done by KSEBL under the direction of KSDMA and based on the weather data provided by Indian Meteorological Department (IMD), on a most critical path without having any definite idea about the exact spread of rainfall, its intensity and quantum of precipitation which are essential to estimate in advance the amount of actual inflow of water expected into the reservoirs. The parameters available were the instantaneous inflow estimated based on the actual reservoir levels, reservoir level capacity curves and the design details of dams.

The critical path management of dam safety and operations was satisfactorily carried out with available data despite heavy flooding and inundation of the river basins. A report on the Kerala Floods 2018 by the Central Water Commission (CWC), the apex body under the Government of India, published in September, 2018 has also corroborated that the dams in Kerala have in no way contributed to the floods but have

	attenuated or at least helped to contain a portion of the flood. A peer reviewed simulation study conducted by the IIT Madras (Current Science, Vol.116, No.5, 10 March 2019) also appreciated the role of dams in attenuating the floods.
3.6. Assessment of impact of dam spillage on flooding in downstream areas Audit evaluated the relative contributions of the spills from the two major dams, Idukki and Idamalayar, to the flood flow observed at Neeleswaram gauge station, based on observed data. Contribution of the spills from Mullaperiyar dam to the Idukki inflows was also examined. Data on reservoir inflows, power house (PH) discharge, spills, storage and water levels at the dams, barrage and flow gauges provided by the KSEBL, CWC and Irrigation Department was used to assess the impact of the spills on the floods. Since observed flow and river level data was available at Neeleswaram gauge station, the spills from the reservoirs were compared with the observed flow at Neeleswaram to assess the impact of spills on the floods. The percentage contribution of the reservoir spills, on a daily scale, to the Neeleswaram gauge station is shown in Table 3.4.	Table 3.4 of the Audit Report shows the contribution of daily spills from Idukki & Idamalayar dams to the observed flow at Neeleswaram gauging station. It is evident from the above table that the contribution from spills of the above two reservoirs were 36.12%, 29.54% and 23.44% on 15th, 16th and 17th August 2018 respectively wherein the Periyar River Basin downstream had experienced its extreme flooding. Though the reservoir spills contributed 46.43% of the total flow observed at Neeleswaram on 14th August 2018, it is worth mentioning that the river did not flow crossing its banks then. From the above data, it is evident that more than the spills from the reservoirs, the unregulated catchment's substantial contribution, around two-third of the total volume of the flood, had contributed to the extreme flood event in the Periyar basin. Also, in an extreme flood situation similar to the 2018 floods, ie, once in a hundred-year event, the dams could not attenuate the floods completely with its limited storage capacity. No reservoir system can offer unlimited capacity to absorb the floods and all the dams are designed with an allowable risk acceptance criteria. Even then KSEBL's Idukki reservoir had, in fact provided an attenuation of flood peak by about 1,030 cumecs when peak inflow impinged the reservoir. This is rightly appreciated by the Central Water Commission in their flood report of September, 2018. It is evident from Table 3.5 of the Audit Report that the contribution of spills from Mullaperiyar to Idukki inflow was ranged between 27.98% to 36.62% between the extreme rainfall days of 15th to 17th of the August 2018. Also Audit on record appreciated that if there was no sudden release of 169.79 MCM water from Mullaperiyar during the extreme flood situation, the attenuation of downstream flood would have more significant. The above findings by the Audit also endorses CWC's finding that the release fr..n

Table 3.4: Contribution of daily spills from Idukki and Idamalayar dams to the observed flow at Neeleswaram gauge station

Date	Total observed spills from Idukki and Idamalayar dams (MCM)*	Flow observed at Neeleswaram (MCM)	Contribution of total spills from Idukki and Idamalayar dams to flow at Neeleswaram (per cent)
1	2	3	[(2) / (3)] * 100
14.08.2018	91.06	196.13	46.43
15.08.2018	192.47	532.83	36.12
16.08.2018	234.53	793.93	29.54
17.08.2018	185.85	796.44	23.34
18.08.2018	104.11	612.75	16.99

*The spills presented for Idukki and Idamalayar dams for a day correspond to the observed flow during the 24 hours from 7 AM on that day to 7 AM on the next day.

(Source : Report of IISc, Bangalore)

The contribution of the spills from Idamalayar and Idukki dams together, to the flows at Neeleswaram gauge station during the period 14 to 18 August 2018 was significant at 46.43 per cent, 36.12 per cent, 29.54 per cent, 23.34 per cent and 16.99 per cent respectively, though as the extreme rainfall event continued for a few days, the contribution of the spills in percentage terms is seen to reservoirs had only minor role in flood augmentation as released volume from the reservoirs were almost similar to inflow volumes.

have declined.

Further, as the spills from the Mullaperiyar dam pass through the Vandiperiyar gauge station and subsequently contribute to the inflows to the Idukki reservoir, the role of spills from Mullaperiyar dam in the escalation of flows at Idukki reservoir during the flood period was also examined as shown in **Table 3.5.**

Table 3.5: Contribution of spills from Mullaperiyar dam to Idukki inflows

Date	Spills from Mullaperiyar dam (MCM)	Inflows observed at Idukki dam (MCM)*	Contribution of spills from Mullaperiyar to Idukki inflows (per cent)
1	2	3	[(2) / (3)] * 100
14.08.2018	2.17	84.18	2.58
15.08.2018	46.10	165.06	27.93
16.08.2018	56.74	154.96	36.62
17.08.2018	33.87	111.70	30.32
18.08.2018	33.26	92.51	35.95

*The flow data presented for Idukki and Mullaperiyar dam correspond to the observed flow during the 24 hours from 7 AM on that day to 7 AM on the next day.

(Source : Report of IISc, Bangalore)

As evident from the table, the operation of the Mullaperiyar dam had a negligible effect on 14 August but its contribution to the inflows at Idukki was significant during 15 to 18 August (>20 per cent), considering the magnitude of the floods.

Government in its response stated (September 2020) that the contribution of Mullaperiyar dam to the inflows of Idukki during the period of severe floods from 15-18 August 2018 was very significant. Since sudden and unexpected releases from Mullaperiyar dam by Tamil Nadu Government was expected any moment without notice and the quantum of inflow to Idukki reservoir was not known in advance, KSEBL had to provide sufficient flood cushion to ensure safety of the dam as well as controlled release. But for the sudden release of 169.97 MCM of water from Mullaperiyar during the extreme flood days, the attenuation of downstream flood would have been more significant.

The departmental response indicates the need to prioritise and have in place an integrated reservoir management plan, particularly in multi dam basins. This is significant both because i) the control of reservoir/ dam operations in the State is distributed among KSEBL and the Irrigation department and ii) there is the likely impact of spills from dams under the control of one State in the downstream reservoirs and rivers of another State.

The National Disaster Management Plan lists among the responsibilities of the State (in the context of understanding floods), the implementing and monitoring of flood preparedness, river basin and reservoir management plans including updating rule curves and improving the system of water release from reservoirs.

Audit examined the aspect of the compliance of dam operators to rule curves and the findings are as follows.

3.6.1. Compliance of dam owners to rule curves

A Rule Curve or rule level specifies the storage or empty space to be maintained in a reservoir during different times of the year with the assumption that a reservoir can best satisfy its purposes if these storage levels are maintained. The rule curve as such does not give the amount of water to be released from the reservoir as it will be dependent on the amount of inflows and other extractions. The rule curves are generally derived by operation studies using historic or generated flows. Though it is always desirable to fill a reservoir up to Full Reservoir Level (FRL) (or upto Maximum Water Level (MWL) during emergency situations, if the dam is structurally stable), it is generally recommended that some spill should be made from the reservoir to keep up the downstream river channel and to avoid encroachment in the river.

During field visit, the IISc team accompanied by Audit personnel were informed by KSEBL that no rule curve was followed for reservoir operations during the flood period. However, Audit noticed that KSEBL had in its possession the Rule Curve framed in 1983 **(Appendix 3.2).** Audit observed that only after the floods of 2018, KSEBL developed new rule curves (KSEBL, 2019) which were updated in 2020 (KSEBL, 2020) though the Operation of Reservoir – Guidelines envisaged (Paragraph 5.0) that the rule curves are to be reviewed constantly and if necessary, modified so as to have the best operation of reservoirs.

Audit made available to IISc, the rule curves (1983 and 2020) for the Idukki dam along with the rule curves for the operation of the Idamalayar reservoir (2020) (**Appendix 3.3**), for carrying out simulations of reservoir operation to determine the volume of spills that would have resulted if these rule curves were followed during the flood period. The simulations of the reservoir operation were carried out for the period June to September 2018. The steps

As per the Upper Rule Curve of Idukki reservoir of 1983, the reservoir can be raised up to its FRL by July end. The above upper rule curve was formulated treating Idukki reservoir as a conservation reservoir. As Idukki reservoir is being operated as a conservation reservoir since its inception, wherein no spilling of water over the spillway will normally be permitted until FRL is reached (See (Clause 4.1.1.b of IS 7323-1994). Normally two monsoons combined inflow is required to fill the Idukki reservoir and it spilled only twice before 2018 floods. But both occasions the spills were happened during the fag end of North-East monsoon and the quantum of the spills were quite insignificant. Before the extreme flood event of 2018, Idukki never filled up to its full capacity in middle of August since its inception.

However, considering the high storage position of the reservoirs, KSEBL management had decided to start spill Idukki reservoir at 2399 ft (4ft below its FRL) prior to the extreme floods of 2018, even when the 1983 rule curve permitted a storage up to FRL of 2403 ft. But the extreme intensity of the 2018 floods proven that the provided dynamic flood cushion of 4 ft then was not enough to moderate the above flood.

KSEBL reviewed the rule curves of all major reservoirs with more than 200 MCM (including Idukki) in 2019 including the observed flood data of 2018 floods and also considering the recommendation of CWC. The same was further modified in 2020 based on the professional opinion of the CWC.

followed in simulating the reservoir operation are given in **Appendix 3.4**. The results of the simulations are given below.

3.6.2. Operation of Idukki reservoir using the 1983 rule curve

The Idukki reservoir operation was simulated with the rule curves developed in the years 1983 (Appendix 3.5) and 2020 (Appendix 3.6) to determine the quantum of spills and to compare these spills with the actual spills that occurred during the 2018 flood period. Table 3.6 shows the observed spills at Idukki dam during the flood period and the spills if the rule curves of 1983 were followed.

Table 3.6: Comparison between actual spills and the spills simulated using the rule curves of 1983 for Idukki dam

Date	Actual spills 2018 (MCM)**	Spills when rule levels are applied (MCM) Initial storage level for simulation (starting date – June 30)		
		Upper Rule Level"	Lower Rule Level*	Actual Storage Level""
14.08.2018	46.26	74.06	0.00	74.06
15.08.2018	111.24	154.94	0.00	154.94
16.08.2018	124.65	144.88	123.82	144.88
17.08.2018	115.20	101.59	101.59	101.59
18.08.2018	70.16	82.72	82.72	82.72
Total	467.51	558.19	308.13	558.19

"Start with upper level; Spills computed once storage crosses upper level

Start with lower level; Spills computed once storage crosses upper

Table 3.6 of the Audit Report based on the simulation done by IISc, Bangalore is conclusively proved that the decision of KSEBL Management to create a dynamic flood cushion of 4 ft in Idukki reservoir prior to 2018 floods, rather than following 1983 rule curves, helped to moderate the intensity of the actual spilling to a certain extent.

level
“”Start with actual level; Spills computed once storage crosses upper level
**The actual spills (2018) presented for a particular day are the observed
spills during the 24 hours from 7 AM on that day to 7 AM on the next day
(Simulations were carried out from June to September 2018; results for the flood period alone are shown)
(Spills are accounted only if the simulated level exceeds the crest level)
(Source : Report of IISc, Bangalore)

The simulations revealed that the spills from Idukki reservoir during the flood period (14-18 August) would have been higher (558.19 MCM against the actual spills of 467.51 MCM) if the simulations started with the actual storage level or the upper rule level. Thus, for reservoir operations during the floods of 2018, the rule curve of 1983 for Idukki reservoir could not have been relied upon to achieve minimal or no spills. This shows the necessity for ensuring rule curves are regularly updated as required by the National Disaster Management Plan and by the Reservoir Operation Guidelines. In the case of Idamalayar reservoir, there was no rule curve in place at the time of the 2018 floods for the guidance of dam operators.

However, subsequent to the floods of 2018, and based on the Central Water Commission's recommendations in their Study Report on 'Kerala Floods of 2018' to review rule curves for major reservoirs in the State, the existing rule curves were reviewed by KSEB. Subsequently, rule levels as prepared by CWC were approved by the Government of Kerala in May 2020. KSEBL also resolved to give approval to the modified rule levels prepared by CWC for operation of Idukki, Idamalayar, Kakki and Banasurasagar reservoirs. Audit also noted that in the new O&M Manual, reservoir operation

protocols including "rule curves" were included.

3.6.3. Dam operations based on 2020 rule curves

In order to see how the application of Rule curve of 2020 for Idukki dam operations would impact spills from the reservoir in case a scenario similar to the floods of August 2018 were to happen again, simulation studies were carried out. Simulation of the reservoir operation of Idukki reservoir shows that if it was operated according to the rule curve of 2020, the spills from the reservoir during the flood period would be 531.03 MCM which is higher than the actual spills of 467.51 MCM (14-18 August, 2018) as shown in Table 3.7.

Table 3.7: Comparison between actual spills and the spills simulated using the rule curve of 2020 for Idukki dam

Date	Actual spills 2018 (MCM)**	Spills when rule level is applied (MCM) Initial storage level for simulation (starting date – June 10)	
		Rule Level"	Actual Storage Level""
14.08.2018	46.26	68.63	68.63
15.08.2018	111.24	149.51	149.51
16.08.2018	124.65	139.45	139.45
17.08.2018	115.20	96.16	96.16
18.08.2018	70.16	77.29	77.29
Total	467.51	531.03	531.03

"Start with rule level; Spills computed once storage crosses rule

CWC reviewed the above rule curves submitted by KSEBL based on the national norms and new flood data of 2018. The revised rule curves recommended by CWC was implemented by the KSEBL in 2020 and the reservoir operation since 2020-2021 was being done based on this revised rule curves.

As per the revised rule curve, Idukki reservoir is provided with a dynamic flood cushion of 16.19 ft (270.63 MCM) at 2386.91 ft between 11 to 20 August. The very purpose of the dynamic flood cushion is to accommodate a good portion of the flood in the reservoir transiently during flood times and distribute it over a long period rather than discharging the same then and there.

Audit had relied a simulation study done by the IISc, Bangalore which blindly discharged all flood waters then and there, whenever it is crossing the rule curve, rather than transiently storing the flood waters in the dynamic flood cushion zone. The above simulation studies relied by the Audit lead to an incorrect conclusion that if the rule curve of 2020 were followed in Idukki, the spills would have been more than the actual spills. The above simulation operation done by IISc, is applicable only if the water level in the reservoir is at FRL or above and not in the dynamic flood cushion zone.

If all flood waters are discharged to the downstream river then and there, when the rule levels are being crossed, even when sufficient dynamic flood cushion is available, then the upper rule curves are wrongly treated as full reservoir levels, thereby defeating the very purpose of the dynamic flood cushion. The non accounting of the dynamic flood cushion is a fatal error that had vitiated the IISc accounts.

Audit's inference that introduction of 4 ft dynamic flood cushion prior to 2018 floods did not prevent spills fo 467 MCM failed to acknowledge the very fact inferred by them that such an action had reduced the spills from 558.19 MCM to 467 MCM (See Table 3.6). When the upper rule curve and FRL becomes one and same, then no regulation is

level
*Start with actual level; Spills computed once storage crosses rule level
**The actual spills (2018) presented for a particular day are the observed
spills during the 24 hours from 7 AM on that day to 7 AM on the next day
(Simulations were carried out from June to September 2018; results for the flood period alone are shown)
(Spills are accounted only if the simulated level exceeds the crest level)
(Source : Report of IISc, Bangalore)

When the exercise was carried out similarly (Appendix 3.7) for Idamalayar dam using the new rule curve of 2020, the study indicated that the spills when reservoir operations were carried out using the rule curve would be lesser than the actual spills in 2018. Table 3.8 shows the observed spills at Idamalayar dam during the flood period and the spills if the rule curve of 2020 is followed.

Table 3.8: Comparison between actual spills and the spills simulated using the rule curve of 2020 for Idamalayar dam

Date	Actual spills 2018 (MCM)**	Spills when rule level are applied (MCM) Initial storage level for simulation (starting date – June 10)	
		Rule Level"	Actual Storage Level""
14.08.2018	44.80	56.13	56.13
15.08.2018	81.23	97.20	97.20
16.08.2018	109.88	85.54	85.54
17.08.2018	70.65	51.24	51.24

advisable and outflow equals the inflow.

The 2020 rule levels were reviewed by the CWC after scrupulously examining the hydrology data of 2018 floods and also giving due weightage to the various multipurpose needs for which the above reservoirs are constructed and maintained. It is an elaborate hydrological exercise carried out by the domain experts and the dynamic flood cushion provided in those reservoirs were further tested by CWC using different frequencies of floods as per the established national norms. **However, KSEBL assure the rule curves will be regularly reviewed based on the observed hydrology data in consultation with CWC.**

Audit has approached the concept of "outflow should not be more than the inflow" in a skewed manner by isolating and comparing the daily volumes of inflow and outflow, rather than rightly considering the total inflow and outflow during the entire flood. We submit that this is conjectural bereft of the benefit of a nuanced analysis.

First of all, flood is all about the rate of discharge rather than the volume, flooding happens when flood discharge exceeds the channel capacity. It is evident from Audit's acknowledgement of the KSEBL's response "The reservoir operation at both Idukki and Idamalyar helped to attenuate the peak flood discharges. Then when an extreme storm like 2018 happens, the reservoirs have major constraints to accommodate the flood water fully there as it may lead to over topping of the dam and eventually lead to dam break. During such occasions, though at times even when the downstream conditions are not favorable for releases, the dam mangers are left with no choice but to effect the spillway releases considering the crucial question of dam safety".

A Flood hydro graph has two distinct phases, one is a rising limb and the other one is a recession limb. Dam mangers operate spillway and discharge flood water in a manner that the outflow may not be more than the inflow in the rising limb, where we will have the maximum flood peak. The difference from the hourly peak inflow to the maximum discharge made through spillway at that time is known as "attenuation". If a reservoir operation resulted in attenuation, it must be inferred that it moderated the flood rather than worsening the nature.

In contrast, when the flood wave is receding, naturally the outflow will exceed the inflow in the recession limb, such an operation cannot be termed as "worsening the

18.08.2018	**33.94**	**33.38**	**33.38**
Total	**340.50**	**323.49**	**323.49**

"Start with rule level; Spills computed once storage crosses rule level
*Start with actual level; Spills computed once storage crosses rule level
**The actual spills (2018) presented for a particular day are the observed
spills during the 24 hours from 7 AM on that day to 7 AM on the next day
(Simulations were carried out from June to September 2018; results for the flood period alone are shown)
(Spills are accounted only if the simulated level exceeds the crest level)
(Source : Report of IISc, Bangalore)

It is observed that if the Idamalayar reservoir was operated according to the rule curve of 2020, the spills from the reservoir during the flood period (14-18 August, 2018) would be 323.49 MCM (less than the actual spills of 340.50 MCM). Even if the rule curve of 2020 was followed considering the observed actual level on June 10 for initialization, the spills during the flood period would still have been 323.49 MCM which is less than the actual spills of 340.50 MCM.

Hence, the simulation studies using the 2020 rule curve for Idamalayar gave a result indicating lesser spills unlike in the case of Idukki.

The Department in its reply (December 2020) said that as per the rule curve of 2020, the water level to be maintained at the Idukki

nature". This is evident from the inflow and outflow graphs provided in the (Extracts from the book "Hydrology and Water Resources Engineering', K.C.Patra **(Annexure - 1)** and also Fig.2 of the IS:5477 (Part IV) – 1971, Methods for Fixing the Capacities of Reservoirs **(Annexure-2).**

This is the standard operating procedure in real time reservoir operation and the clause 5.1.3 of IS 7323:1994 clearly endorses that:

"In all cases, procedure for releasing the stored water after the flood has passed would also be laid down in the schedule. In order to vacate the reservoirs as quickly as possible for routing the subsequent floods".

Hence audit observation about the increased flow in the recession limb does not sustain.

reservoir during 11 to 20 August is 2,386.81 feet with 1,725.71 MCM. This would give a dynamic flood cushion of 270.63 MCM (upto FRL 2,403 ft). The dynamic flood cushion would enable the dam managers to transiently accommodate the heavy inflow into the reservoir during the flooding period and distribute the consequent spill in a regulated manner.

Audit notes that even after a considered decision by KSEBL in consultation with KSDMA in August 2018 to introduce a dynamic flood cushion of four feet below FRL (68.87 MCM) (the rule curve of 1983 for Idukki reservoir permitted KSEBL to store water during the month of August 2018 upto FRL), spills of 467 MCM could not be avoided. Audit also saw that despite such decision, the outflow did exceed inflow in respect of Idamalayar reservoir on two days (16-17 August, 2018) and in respect of Idukki on one day (17 August 2018).

Hence, KSEBL may consider the feasibility of conducting simulation or other studies to ensure that the approved rule curve of 2020 along with provision of dynamic flood cushion would suffice to handle situations similar to the extreme rain event of 2018 with minimal spills, if any.

Need for assurance about the adequacy of the new rule curves is emphasised also because IISc's studies to examine the effect of reservoir spills on the flood inundation depth and extent showed that if the discharge from Bhoothathankettu barrage consisted only of the runoff generated with heavy rainfall, the extent of simulated flood spread would have reduced from 520.04 sq. km to 441.44 sq. km and the maximum simulated depth (with respect to ground level) at Neeleswaram would have reduced from 12.32 m to 9.68 m. KSEBL acknowledged (June 2020) that the 15 per cent reduction of area was a realistic assessment.

The Secretary, Power Department (December 2020) in his response to the audit observation said that the methodology followed by

KSEBL in controlling the flow is to operate within the dynamic flood cushion below the FRL and ensure that the levels do not exceed the FRL. Keeping in view this principle, the inflow and outflow in both Idukki and Idamalayar were coordinated. While so coordinating, the sudden inflow without notice from Mullaperiyar as well had to be reckoned. Still the crisis situation was managed well within the prescribed parameters. In Idamalayar on 15 August 2018, the FRL was breached by 0.15 m and the outflow maintained was less than inflow and on 16 August 2018 the FRL was again breached by 0.75m and still the outflow was maintained at a lower level. At that point of time, due to the extreme flood situation, the inflow increased drastically and there was no other alternative but to increase the outflow to maintain the FRL, considering the safety of dam, as well. The Secretary, Power Department further stated that the position as explained above would indicate that the reservoir operation in the crisis situation was prudently managed and spills were maintained at optimum levels.

The Government vide letter dated 16 April 2021 also informed that in the case of Idamalayar reservoir, the difference between total outflow and total inflow was only 9.86 MCM which is only 2.90 per cent of the total inflow of 338 MCM into this reservoir. Considering the total combined inflows of 946.40 MCM (608.40 + 338), a total combined outflow of 815.37 MCM (excluding PH discharge from Idukki reservoir) was only discharged to the Periyar basin from both reservoirs (between 14 and 18 August 2018). The integrated operation by KSEBL resulted in moderation of 131.03 MCM. KSEBL had let the outflow exceed inflow only in the recession limb of the flood hydrograph which is a standard operation procedure. The response indicated that in Idamalayar, for five hours on 15 August 2018, the outflow was marginally more than the inflow (in the rising limb of the flood hydrograph) but this was before the flood hydrograph's sharp rising and touching its peak inflow. This was unavoidable as Idamalayar reservoir levels breached its FRL nd integrated reservoir operation necessitated such release.

Attenuation of 1,128 cumecs when the peak inflow of 2,328 cumecs occurred at 03:00 hrs on 16 August 2018 in Idamalayar reservoir was also pointed out. Further, as Idukki PH discharges to the adjacent Muvattupuzha basin and not to Periyar basin, the same should not be added to the outflows to the Periyar basin. The departmental reply above seeks to indicate that spills that took place, including outflow exceeding inflow (on two days in the case of Idamalayar reservoir and one in Idukki reservoir), during the August 2018 floods were optimal and acceptable given the circumstances such as inflow from Mullaperiyar without warning and the fact that the outflow exceeded the inflow on the receding limb. However, the KSEB's response that outflow exceeds inflow only in the receding limb, is silent about the downstream conditions. The Neeleswaram CWC Gauge station in the month of August 2018 recorded very high-water flow on 15 and 16 August (as well as on 17 and 18 August). On all these days (15 to 18 August 2018), the flow (refer Table 3.4 of this Report) exceeded 363 MCM/day which was adequate for the river to breach its banks. The water level as measured at Neeleswaram CWC Gauge station on 16, 17 and 18 August was similarly very high at 12.10 m, 12.12 m and 10.55 m respectively when compared to average water level of 4.55 m for the month of August 2018. Thus, the release of water from the dams so close to the peak inflow (even if it was in the recession limb) could aggravate the flood situation downstream. Further, on 17 August 2018, the hourly data indicates that the outflows from Idukki dam exceeded the inflows during 16 hours of the day and on 16 and 17 August, the outflows from Idamalayar reservoir exceeded the inflows for 10 and 21 hours of the day respectively. Besides, even if PH discharge were to be excluded for Idukki, the net inflow would be negative (-3.50 MCM) for Idukki on 17 August. Further, in the case of Idamalayar, though attenuation occurred at peak inflow, the fact is that net inflow over the 14-18 August period was negative (-9.86 MCM). Besides, the Guidelines for operation of spillway gates of Cheruthoni dam (1990) specify that outflow is never to exceed	

inflow except under emergencies and when the reservoir is to be depleted to the desired level. Thus, Audit feels that it cannot be cited as a standard operating procedure, even during the receding limb of a flood hydrograph, particularly so close to the peak inflow.

Hence, Audit reiterates the need for assurance about the adequacy of the new rule curve along with the provision of dynamic flood cushion given the fact that the frequency of incidents of excessive rainfall and flooding in the State has increased in recent years. As the rainfalls in July 2018 had resulted in an average inflow of 25 MCM per day to Idukki and the average inflow to Idukki between 09 August 2018 and 19 August 2018 was more than three times and of the order of 79 MCM per day, which was unprecedented in the history of the dam, there is an urgent need to be prepared for such extreme rainfall events in the future including through establishment of inflow forecasting stations. The possibility of unscheduled releases from upstream reservoirs also needs to be considered along with the factoring of downstream conditions. It is desirable further to develop the rule curves keeping in view the integrated operation of the major reservoirs in the basin. Rule curves developed considering various aspects including integrated operation of reservoirs would provide more assurance.

Recommendation 3.5:

a) KSEB may ensure flood release operations for reservoirs are based on approved rule curves which further need to be regularly reviewed and updated.

b) KSEB may conduct simulation or other studies to ensure that the approved rule curves of 2020 for Idukki and Idamalayar would be adequate to handle situations similar to the extreme rainfall event of 2018, without consequential flooding.

c) Feasibility of putting in place rule curves based on integrated operation of reservoirs within an approved time frame must also

KSEBL is operating the major reservoirs based on Rule curve approved vide G.O. (Rt) No. 64/2020/Power dated 21.05.2020. KSEBL has conducted a scenario analysis for Idukki reservoir for the period from 2013 – 2022.

Requested the Central Project Management Unit (CPMU) for DRIP, Central Water Commission (CWC) for assistance to develop an operational strategy for the real time operation of Idukki reservoir by developing an Inflow Forecasting model and updating the Rule Levels of Idukki reservoir through the International Centre of Excellence for Dams (ICED) at IIT Roorkee under DRIP. CPMU has informed that they are in the process of taking up with the ICEDs and other Institutes with which MoA is either

be considered.

3.7. Siltation of reservoirs and reduction in storage capacity

Dams and Reservoirs are subject to siltation. Sedimentation causes loss of active storage volume, and thus reduced ability to compensate for outflows for hydro power, irrigation, drinking water and flood retention. Uncontrolled deforestation, forest-fires, overgrazing, improper methods of tillage, unwise agriculture practices and other activities are mainly responsible for accelerated soil erosion which causes siltation in dams. Paragraph 7.10 of Reservoir Operation Guidelines issued by the Bureau of Indian Standards requires capacity surveys of reservoirs to be undertaken once in three to five years or when the loss of capacity was five per cent, whichever was earlier.

- Audit observed that of the 18 reservoirs under the ownership of KSEBL, sedimentation studies of only 11 were carried out during the period from 1989 to 2011. As on the date of audit (August 2019), no capacity surveys or sedimentation studies were conducted in any of the KSEBL reservoirs after 2011. Though the sedimentation surveys (in 2007 and 1995 respectively) indicated significant capacity loss as in Kallarkutty dam (47 per cent of gross storage in 45 years) and Anayirankal reservoir (30.92 per cent in 33 years), KSEBL had not conducted any further study to assess the change in silt deposit and reduction in the capacity of the dams. Though KSEBL identified (2010) six dams for conducting desiltation, none of them had been desilted till the date of audit (August 2019).

signed or is under process, to provide their consultancy services at nominal charges to the States.

It is proposed to take up the study through CWC, once they finalize the TOR with ICEDs.

Sedimentation of a reservoir is a product of the annual rate of sedimentation and the catchment area. Annual rate of sedimentation is expressed as "Thousand cubic meter of sediment/square kilometer of catchment area/year". In Kerala scenario, our catchment area is very small in comparison with other major reservoirs in the country, hence the percentage reduction of capacity/year is very insignificant.

To illustrate the above point, a table is prepared below from the sedimentation data provided in Appendix-III of the "COMPENDIUM OF SEDIMENTATION OF RESERVOIRS IN INDIA – 2020" published by Central Water Commission. Hence it is clear that percentage reduction of capacity/year is very insignificant in Kerala reservoirs in comparison with other major reservoirs.

Reservoir	Gross Capacity (MCM)	Catchment Area (Square Kilometre)	Annual Rate of Sedimentation (Thousand cum/sqkm/ year)	Loss of Volume/ year (MCM)	% Reduction of Capacity/ Year
Idukki (Kerala)	1996.30	649.31	1.59	1.032	0.05%
Almatti (Karnataka)	3486.00	35926	0.71	25.507	0.73%
Srisailam (Andhra)	8724.88	206030	0.36	74.171	0.85%

Secretary, Power Department stated (September 2020) that the live storage in five major reservoirs viz. Idukki, Idamalayar, Kakki, Banasurasagar and Sholayar (out of 18 reservoirs) constitutes 92.27 per cent. Siltation is negligible in these major reservoirs as its annual storage loss is less than 0.2 per cent as per the sedimentation studies conducted through various agencies. In respect of the eight small reservoirs for which studies were conducted, desilting could not be carried out due to difficulty in depositing removed silt and obtaining permission from Forest Department. The Handbook on assessing and managing reservoir sedimentation published by CWC in February 2019 indicates that the annual storage loss due to sedimentation is significantly low in Kerala reservoirs.

Audit observes that the statement that sedimentation in the five major KSEBL reservoirs is negligible is not based on any recent study or assessment (through CWC or otherwise) as sedimentation assessment of Idukki, Idamalayar, Kakki and Sholayar were conducted during 2004, 2011, 1999 and 2003 respectively. In respect of Banasurasagar reservoir, commissioned during 2005, no sedimentation study is seen conducted. Thus, 9 to 20 years have elapsed since conduct of capacity survey or sedimentation study, even though Reservoir operation guidelines (IS 7323:1994) provide for capacity survey every three to five years.

Kerala State Electricity Board Ltd. informed vide letter dated 01 February 2021 that sedimentation study had been repeated for Poringalkuthu and Kundala reservoirs in 2020. KSEBL also completed sedimentation surveys for five more reservoirs viz. Kallarkutty, Madupetty, Ponmudy, Anayirankal and Sengulam in 2020 but reports of the survey are awaited. Proposals for conducting sedimentation studies for the remaining reservoirs are now included under Dam Rehabilitation and Improvement Project

Hirakud (Odisha)	8105.00	83395	0.62	51.705	0.64%

The annual utilization and flood management depends on the live storage capacity rather than the gross storage capacity. It is a well-known fact that only major reservoirs can play a role in flood absorption during heavy flooding years, as small reservoirs used to spill in most of the years, except in drought years.

It can be deduced from the hydrographic survey data of the above mentioned CWC publication that the total live storage capacity lost due to sedimentation from Idukki reservoir till 2021 (47 years) is just 1.128%, which translates to 16.487 MCM, Similarly, the loss of live storage capacity for Idamalayar is just 1.404 MCM. The above loss of capacity shall be compared with the total inflow 1925 MCM (CWC, 2018) generated in 15-17 August 2018 of Kerala floods in the Periyar basin.

From the above data, it is evident that sedimentation of reservoirs does not have any significant impact on the flood absorption capacity of KSEBL reservoirs.

KSEBL owns and operates 18 reservoirs for hydro power generation with varying live storage capacities from 0.39 to 1460 Millin Cubic Meter (MCM). Out of these, the live storage in five major reservoirs viz, Idukki, Idamalayar, Kakki and Banasurasagar & Sholayar constitutes 92.27%. Silting in these major reservoirs is insignificant as its annual storage loss (ASL) is less than 0.2% as per the sedimentation studies conducted through various agencies (See **Annexure 3).**

As per the Erosion and Sedimentation Manual published by U.S Department of Interior Bureau of Reclamation November 2006, Large reservoirs require less frequent Surveys. A decision on when to schedule and at what frequency to conduct a reservoir survey are on a case – by – case basis. Another reason is that the big reservoirs like Idukki reach close to its full capacity only once or twice in a decade, so the hydrographic survey at FRL is not possible at five year intervals. Hence, it is natural that frequency can be extended upto 20 years interval, if rate of sedimentation is not significant.

The latest status of sedimentation studies and desiltation of KSEBL reservoirs is as

(DRIP) - II and submitted to CWC for their approval. Chief Engineer (Civil – Dam Safety and DRIP) further stated (February 2021) in the backdrop of the 2018 floods that it was decided to carry out the sedimentation study for Idukki, Idamalayar, Kakki, Banasurasagar and Sholayar reservoirs and the same is included in Dam Rehabilitation and Improvement Project-II.

- Audit observed that the position was slightly better in the case of 20 reservoirs under the control of the Water Resources Department. Siltation study was conducted in respect of all these reservoirs. The study revealed significant levels of siltation in Aruvikkara reservoir (43 per cent), Mangalam reservoir (21.98 per cent), Peppara reservoir (21.70 per cent) etc. However, desiltation activities were not undertaken in any of these reservoirs. Though sanction was accorded (September 2017) by GoK for desiltation of Mangalam and Chulliyar reservoirs, the works were yet to commence as of the date of audit (November 2019).

In its reply, the Water Resources Department (November 2020) stated that silting was generally less in Irrigation dams. However, Audit observed that sedimentation in Peppara, Mangalam and Kanjirampuzha reservoirs of 21.70, 21.98 and 21.27 per cent of its storage capacity was significant. During the Exit Conference (02 February 2021) and subsequently, vide letter from ACS, Water Resources Department dated 19 April 2021, Audit was informed that the desilting of Mangalam dam commenced in the first week of December 2020 and that of Meenkara, Valayar and Chulliyar reservoirs entrusted to Kerala State Mineral Development Corporation Ltd. and Kerala Irrigation Infrastructure Development Corporation. With respect to Kanjirappuzha reservoir, bathymetric survey has been completed. Administrative sanction was accorded for the desiltation of Aruvikkara reservoir in January 2021 and two bids received are under consideration of the High-Level Empowered Committee. Further, though all efforts are taken to get the dams desilted, as follows:

- The Sedimentation study of major reservoirs Idukki, Idamalayar, Kakki are being done by Central Water Commission. The ASL is less than 0.2% in these reservoirs. Now CWC is in the process of inviting tender for conducting sedimentation study of Idukki, Idamalayar, Kakki and Banasurasagar (Kuttiyadi Augumentation) reservoirs under National Hydrology Project (NHP).
- Storage assessment of 7 reservoirs were done during 2020 and the details are shown in **ANNEXURE-4.**
- Tender has already invited for conducting bathymetric survey of Pamba, Kakkayam and Moozhiyar reservoirs under DRIP-II. Also work order to conduct bathymetric survey of Sholayar reservoir is issued to Kerala Engineering Research Institute (KERI) under Water Resources Department, GoK.
- Desiltation of Lower Periyar even though awarded to M/s Travancore Cements Limited could not be carried out as the forest land required for stacking and segregating the sediments are not yet diverted from the Forest Department to M/s Travancore Cements Limited.
- The KSEBL has constituted a committee for the preparation of draft Standard Operating Procedure (SOP) for the desiltation of reservoirs of KSEBL, preparation of Detailed Project Report and completing the pre activities of desiltation for Kallarkutty reservoir etc. as per BO (FTD)No.449/2021 (DGC/AEE-II/Desiltation/2015 dated 17.06.2021.

Accordingly, the committee had prepared a draft SOP for the desiltation of reservoirs of KSEBL after making appropriate changes in the form of additions, deletions and modifications to the Clauses of SOP of Irrigation Department to suit with the requirements of KSEBL.

Modified SOP for the desiltation of KSEBL reservoirs in line with the SOP published by Government of Kerala vide G.O. (MS) No.79/2017/WRD dated 26.09.2017 & G.O. (MS) No.14/2019/WRD dated 14.05.2019 furnished by KSEBL is under process ...

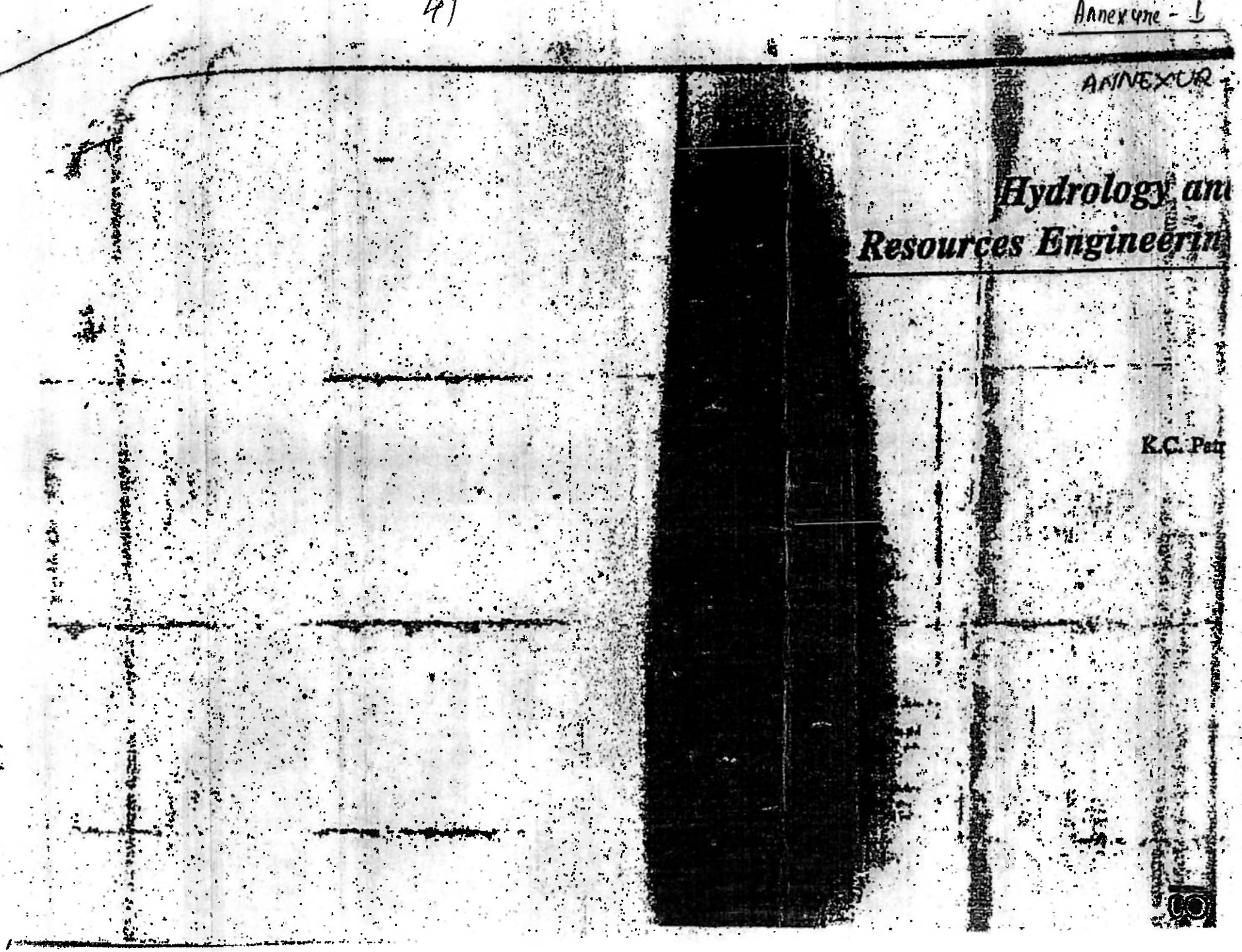
the participation in tendering process was very low, the works had to be retendered more than once. ACS also stated that with the constitution of River Basin Conservation and Management Authority, the coordination work could be institutionalised and turned into a regular process.	Water Resources (MP) Department for the approval of Empowered Committee.
Recommendation 3.6: In view of the possible loss of active storage volume of dams through sedimentation and its consequential adverse impact on flood control, KSEB and Irrigation Department may ensure that sedimentation studies as prescribed in Reservoir Operation Guidelines issued by Bureau of Indian Standards are conducted and timely action taken to arrest the capacity loss of reservoirs.	KSEBL has conducted sedimentation survey of 16 reservoirs and the details are atached as **Annexure 5** From the survey conducted, major loss in storage is observed at Vellathooval & Kallarkutty reservoirs. Detailed Project Report (DPR) for the Desiltation of Vellathooval & Kallarkutty reservoirs were prepared and submitted to the Technical Committee. The Technical committee has recommended the DPR to Empowered Committee for review and approval.The Empowered Committee in the meeting held on 28.06.2024 has considered the DPR and entrusted Water Resources Department (KWRD) to examine the DPR and to place it in the next meeting. The Chief Engineer (I&A), Water Resources Department has conducted a meeting with KSEBL on 19.07.2024 and the DPRs are under review at KWRD.

PREETHY C S
PEN: 101031
Joint Secretary
Power Department
Govt. Secretariat
Thiruvananthapuram

41

Annexure - I

ANNEXUR



Flood Routing

9.1 INTRODUCTION

Flood routing is the process of determining the flood hydrograph at a location downstream of a reservoir or a channel section from the knowledge of the upstream inflow hydrograph. The net effect of the reservoir (or the channel) is to modify the flood hydrograph. When the interest is to know the flood hydrograph from an existing or proposed reservoir then, it is called reservoir routing. On the other hand, if the interest is to know the probable effect of the channel at a downstream location to an inflow hydrograph while it propagates, the process is called channel routing. Hence, routing of floods is broadly classified into two groups viz. (1) channel routing and (2) reservoir routing.

This chapter discusses the various techniques used in routing floods either through a channel or a reservoir. The resultant hydrograph at the downstream location is called *outflow hydrograph*. Routing helps to fix the capacity of the spillway of reservoirs, water control structures, protection works and forecasting of floods for evacuation and other operations. In both the routings, the two distinct modifications that take place to the inflow hydrograph are:

(a) The peak of outflow hydrograph is less than the peak of inflow hydrograph. We call this phenomenon as *attenuation of the peak*. The time base of the hydrograph is increased. It is due to the combined effect of storage and channel friction.

(b) The peak of outflow hydrograph occurs sometime later than the inflow hydrograph. This is called *translation* or *lag* of the peak and is due to the travel time of the flood wave in the channel or reservoir.

The flood is therefore said to be *modified* while passing through a reservoir or a channel. Outflow from a reservoir is directly related to the head over spillway. If more is the head, higher is the discharge over spillway. When flood volume accumulates over a spillway, its head increases and so is the outflow from it. The rate of outflow is always less than the inflow values during the initial period. A plot of the shapes of the inflow and outflow hydrographs are shown in Fig. 9.1. Initially, there is accumulation of inflow flood volumes to build the storage in the section. As storage increases from A to C through B (Fig. 9.1) the outflow also increases slowly, but with lesser rate than the increase of inflow. A stage comes (at point C), when the two curves cross each other. At this point the outflow is max imum as the inflow hydrograph has already reached its peak. After point C, the accumulated inflow hydrograph has already been discharged from the system. Storage represented by the area AHCA is gradually discharged from the system

contained by the channel before the inflow hydrograph arrives at the section. For peaked inflow hydrographs, the attenuation is higher than moderate floods. Channels having wider section at the outlet or for longer routing length of the channels, the reduction in the peak is higher. For steep channels or channels with good storage of water initially, the reduction of peak will be less.

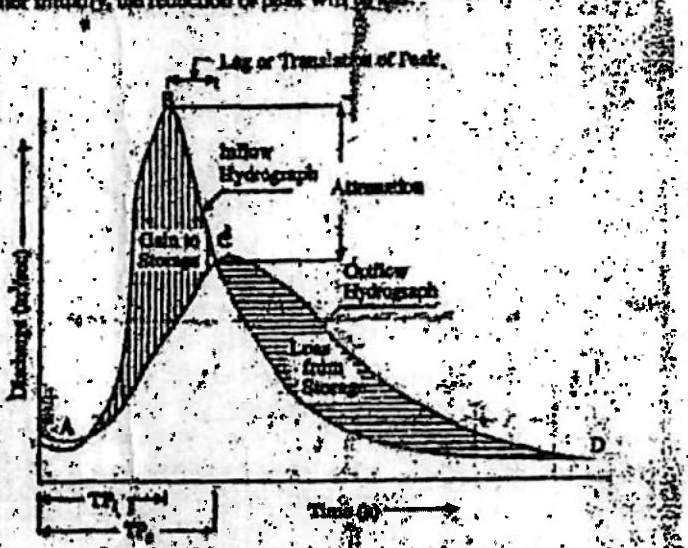


Fig. 9.1. Hydrograph Shapes Before and After Routing

Since the basic idea of routing is to determine the flood hydrograph at a section downstream of a reservoir or a channel from the knowledge of the complete inflow hydrograph upstream of it, some important methods of routings are discussed in this chapter.

9.2 ROUTING METHODS

All the methods available for routing floods in channels and reservoirs are broadly classified into three groups: (1) Hydrologic routing, (2) Hydraulic routing and (3) Routing with flow.

Figure 9.2 illustrates various routing methods employed under each group. Natural channels are so complex that a true picture of flow hydraulics is difficult to obtain through mathematics. Flow through a river reach always involves a varied flow problem and the flow is unsteady. Hydraulic routing methods use the two conservation equations. The model using the conservation of mass and momentum equations in the flow problems always give better results. However

ANNEXURE-2

Indian Standard

METHODS FOR
DETERMINING THE CAPACITIES OF RESERVOIRS

PART IV FLOOD STORAGE

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

b) Full reservoir level;

c) Inflow hydrograph (*see* Fig. 2);

d) Initial outflow; and

e) Initial storage (or initial reservoir level).

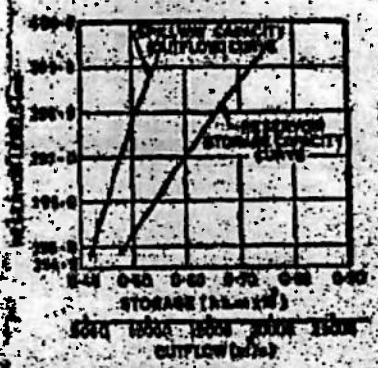


FIG. 1 RESERVOIR LEVELS *VS* SPILLWAY AND STORAGE CHARACTERISTICS

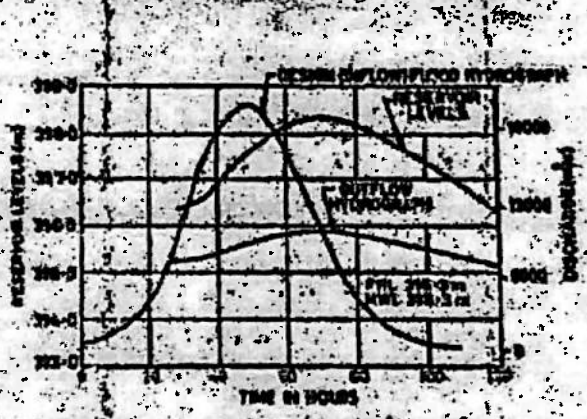


FIG. 2 INFLOW AND OUTFLOW HYDROGRAPHS AND TIME *VS* RESERVOIR LEVELS FOR THE DESIGN FLOOD HYDROGRAPH

ANNEXURE-3

SEDIMENTATION STATUS OF MAJOR RESERVOIRS

Sl No	Name of Reservoir	Year of Study	Reduction in storage	Annual storage loss%	Remarks
1	Idukki	1999	1.59% in 25 years	0.05%	Storage capacity will be soon reassessed by CWC uner NHP
2	Idamalayar	2011	4.75% in 25 years	0.19%	Storage capacity will be soon reassessed by CWC uner NHP
3	Kakki	1999	5.66% in 33 years	0.17%	Storage capacity will be soon reassessed by CWC uner NHP
4	Sholayar	2003	10.77% in 37 years	0.29%	Work Order issued to KERI to reasses the storage capacity
5	Banasurasagar	Reservoir is commissioned in 2006, hence no sedimentation study is yet done			Storage capacity will be soon reassessed by CWC uner NHP

ANNNEXURE -4

SEDIMENTATION SURVEY OF RESERVOIRS CONDUCTED IN 2020

Sl No	Name of Reservoir	Gross storage at FRL (MCM)	Gross storage at FRL as per latest survey (MCM)
1	Kallarkutty	6.80	3.82
2	Anayirankal	50.68	40.88
3	Ponmudi	51.54	41.71
4	Madupetty	55.22	54.07
5	Kundala	7.78	7.46
6	Poringalkuthu	32.00	27.24
7	Sengulam	1.30	No reduction

Annexure I

DETAILS OF SEDIMENTATION STUDY CONDUCTED FOR MAJOR RESERVOIRS						
Sl No.	Name of reservoir	Year of Commissioning	Year of Survey	Original Storage Mm^3	Percentage Loss in Storage	Annual Storage loss in percentage
1	Vellathooval	2017	2023	0.07	74.00	12.33
2	Kallarkutty	1961	2020	6.80	43.79	0.74
3	Kakkayam	1972	2022	38.40	33.00	0.66
4	Moozhiar	1999	2022	1.50	31.00	1.35
5	Anayirankal	1965	2020	50.68	19.34	0.35
6	Ponmudi	1963	2020	51.54	19.08	0.33
7	Lower Periyar	1997	2009	5.30	18.75	1.56
8	Poringalkuthu	1957	2020	32.00	15.00	0.24
9	Kakki	1966	2023	454.14	8.00	0.14
10	Idukki	1976	2023	1998.57	5.00	0.11
11	Kundala	1947	2020	7.65	4.00	0.05
12	Idamalayar	1987	2023	1176.19	3.00	0.08
13	Madupetty	1956	2020	55.23	2.10	0.03
14	Sengulam	1954	2020	1.03	-	-
15	Pamba	1966	2022	39.22	-	-
16	Sholayar	1965	2023	153.48	-	-

Revised RMT received from water Resources Dept

RMT Statement (updated) on the Audit report of the C&AG on Preparedness and Responses to Floods in Kerala.

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(Report No.6 of the year 2021)

Table 2

Audit paragraph	Reply
Paragraph 2.1 Inadequate provision for flood management in the State Water Policy (2008) Water Policy of Government of India, which was formulated in 1987 and revised in 2002 & 2012, provides for preparedness to flood, modernization of flood forecasting using real time data acquisition system linked to forecasting model, evolving and implementing operating procedures for reservoirs in order to have flood cushion, increasing	The audit observation that the State of Kerala did not give priority to flood management in the State, was made by the C&AG based on a comparison between the provisions for flood preparedness in the National Water Policy of 2012 and the State Water Policy of 2008. The observation is not true because the State had given emphasis to flood preparedness in the past irrespective of the position that whether there were provisions for flood preparedness in the State Water Policy 2008 or not. 131 rain gauges, 54 river gauge stations and 9 fully automatic climatic stations, which were set up under the National Hydrology Project, were operational in the State prior to the mega floods of 2018. Water Resources Department had employed Gauge Readers for taking the measurements recorded in the gauging devices on a real time basis. This shows that the State did take measures for flood forecasting and was always vigilant in formulating plans for flood control.

preparedness for sudden and unexpected floods, etc. But the Government of Kerala has not incorporated the flood management provisions in the State Water policy formulated in the year 2008. Non- inclusion of elements of flood control measures in the State Water Policy was indicative of the low priority given to flood management in the State. **Recommendation of C&AG** 'Government of Kerala may consider revision of the State Water Policy to include aspects relating to flood management, in line with the National Water Policy and after considering the specific requirements of the State'.	**Reason for not including adequate provisions for flood management in the State Water Policy at the time of policy formulation.** Kerala State Water Policy was formulated in the year 2008. The State of Kerala never experienced a mega flood as that of 2018 in yesteryears and in the memory of current two to three generations and is needless to say that is the reason for the drafting Committee not to include adequate provisions for flood preparedness in the State Water policy 2008. **Inclusion of provisions for flood preparedness in the State Water policy and the Kerala floods of 2018.** It is an undisputed fact that the mere incorporation of provisions for flood management in the State Water Policy could not have prevented the floods of 2018 as such was the extent of the fury of the flood. As per the hydrological study conducted by the Central Water Commission in September 2018, it was found that the 2018 flood was almost comparable to the severest rainfall of July 1924 of Devikulam. The severest rainfall of such a high magnitude had happened after a huge interval of 94 years and this has made the heavy flood

	unpredictable. It was stated in the report of the CWC on 'Kerala Flood and Solutions' that the 'return period of flood event from 15th to 17th of August 2018 was above 100 year return period flood i.e. having probability less than 1%, while the flood event from 8th to 10th of August 2018 was above 25 year return period flood i.e. having probability more than 4%. The Central Water Commission in its Study Report on 'Kerala Floods of August 2018' as 'unprecedented' and specified that "the release from reservoirs had only minor role in flood augmentation as released volume from the reservoirs were almost similar to inflow volumes and even with the 75 percent filled reservoir conditions, the current flood could not have been mitigated as 1-day rainfall in majority of the area was more than 200 mm and severe rainfall continued for 3 to 4 days". Unprecedented heavy rainfall events in the month of August 2018 made the situation worst giving no opportunity to absorb the flood waters in major reservoirs. Despite a very long shore line, reasonable river bank height and presence of large number of reservoirs, the flood water could not be contained within the river banks and there was large spillage of water in lower reaches of river Periyar and low

	lying areas of other basins as well as Vembanad Lake. It could be said that if a heavy rain fall of identical magnitude happens in the future, similar kind of flooding will definitely occur. As stated earlier, the State of Kerala had maintained flood forecasting stations at the time of 2018 floods and the data generated from these devices had helped in formulating plans for dam operation and issuing flood alerts to the public. It is clear that the absence of adequate provisions for flood management in the State Water Policy did not have an impact on the flood management strategies of the State. **Strengthening of flood forecasting mechanism in the post flood scenario** As aforementioned, flood forecasting stations were functiong in various river basins in the State prior to 2018 floods. In order to equip the State to contain possible future flood events, Government of Kerala developed a full-fledged inflow forecasting and flood early warning system with real time monitoring operational in all river basins through Tipping Bucket Rain Gauges, Radar Level Sensors and Automatic Weather Stations. Out of a total of 168 flood early warning systems purchased already, 97 Tipping Bucket Rain Gauges, 46 Radar Level Sensors and 12 Automatic Weather Stations were installed.

Remaining 13 equipments will soon be installed.

Framing of operation and maintenance manuals for reservoirs

Water Resources Department owns 16 dams. With respect to the audit observation that the State Water Policy should have provision for evolving and implementing operating procedures for reservoirs, it is to be noted that the WRD had already developed O&M manuals for operation and regular maintenance of all dams and inspection activities based on the unique design characteristics of each dam.

Providing Flood Cushion for reservoirs

With respect to the audit remark that the dam operation and maintenance manuals should provide for 'flood cushion', it may be noted that all the dams under WRD have less storage capacity and limited catchment area except Kallada and Malampuzha dams, which have storage capacity beyond 200 MCM. Details of storage capacity and catchment area of 16 dams are shown below:

Sl No.	Dam	storage capacity at	Catchment	Flood Cushion (in Meter)

		Full Reservoir Level (FRL) in MCM	area (Sq. Km)	
1	Malampuzha	226	147.63	-
2	Neyyar	106.25	140	-
3	Kallada	504.92	549	0.91
4	Kanjirapuzha	70.8274	70	-
5	Kuttiyadi	120.52	108.78	-
6	Pothundi	43.891	30.82	-
7	Mangalam	25.494	48.85	-
8	Vazhani	18	20.72	-
9	Peechi	94.946	107.09	-
10	Walayar	18.4	106.355	-
11	Meenkara	11.30	90.65	-
12	Chulliyar	13.7	27.8	-
13	Chimmony	176.78	72.13	0.3
14	Malankara	37	153.5	1
15	Karappuzha	76.5	62	1
16	Siruvani	25	22.47	3

At present flood cushion is available for 5 dams. During the heavy floods of 2018, Water Resource Department was against the idea of utilising the flood

	cushion since these dams have less storage capacity and the flood cushion can be maintained only for a short interval under extreme weather conditions. **Revision of State Water Policy 2008** As per G.O (Rt) No. 24/2021/WRD dated 12.01.2021, drafting Committee for formulating the revised State Water Policy was reconstituted. The drafting Committee has submitted a revised draft of the amended State Water Policy on 05.04.2021. It was conceived that the revised State Water Policy based on state specific requirements and containing the provisions for flood management could be promulgated in 2021. Since certain provisions in the draft policy need more clarity in the wake of extreme environmental impacts caused by the climate change, the drafting Committee was directed to incorporate certain additional provisions and to submit the revised draft at the earliest. On 02.06.2022, Chief Engineer (I&A) and Chief Engineer (IDRB) have been directed to submit the revised draft of the State Water Policy by 31st July 2022.

	<u>UPDATED REPORT</u> : Draft Water policy was under the consideration of Government .The report has following provision relating to floods. • **In chapter 3**-Guiding Principles- Preparation of necessary Plans to address the recurring natural disaster like flood has to be included in the Water Resources Management Plans. • **In Chapter 4**-Basic Strategies-Use of Artifical Intelligence in developing Flood/drought forecasting and early warning system has to be explored. • **In chapter 9 -** Management of Water Resources Projects- Storage capacity of the existing dams may be increased by desilting the sediments accumulated in them-A type of Flood Management. • **In chapter 12**- Adaptation to Climate Change-In context of climatic change the existing. hydraulic and related structures are to be revisited, 2) future structures Shall be planned and designed 3) the specific problems of hilly areas like flash flood shall be adequately addressed 4) dams, flood embankments and tidal embankments shall incorporate

	Strategies keeping the context of climate change. • **In chapter 14 -** Disaster Management in Water Sector-1)The State to recognize the necessity of More Room For River approach to address the natural calamity.2) Early warning systems are to be strengthened to address the effect of flood 3) Promote flood cushion by actively facilitating to preserve and restore playground,ponds ,open wells,paddy fields,wetland etc. • **In chapter 18**-Knowledge Management- Developing a fully functional Water Resources information System to address flood.
Paragraph No. 2.2 Non – preparation of State Level Master Plans for water resources development and management The State Water Policy 2008 envisages the preparation of a State level Master Plan for water resources development and management. Also, it provides for	**Constitution of State level River Basin Conservation and Management Authority (RBCMA)** Vide G.O (MS) No. 30/2020/WRD dated 15.04.2020, Government issued orders in principle for the constitution of a State level River Basin Conservation and Management Authority (RBCMA), which is primed for coordinating all water related activities at the river basin. A draft bill has already been prepared for the constitution of RBCMA. The bill was expected to be introduced in the Legislative Assembly in 2021 but lagged due to want

the preparation of Master Plans for all the major rivers in the State. However, Master Plans for 42 out of 44 rivers are yet to be prepared though envisaged in the State Water Policy 2008. **Recommendation of C&AG** 'Government may ensure compliance with the provisions of the Kerala State Water Policy such as formulation of a State level Master Plan for water resources development and management, formulation of Master Plans for the major rivers besides constituting a State Level Authority to coordinate all water related activities at the river basin level'.	of more clarity with regard to the powers and responsibilities of RBCMA. Meeting of the Drafting Committee will soon be convened and contentious matters will be sorted out so as to present the bill in the State Legislative Assembly at the earliest. **Formulation of State- level Master Plan for water resources development and management** It was envisaged in the State Water Policy 2008 that a State - level Master Plan for water resources development and management shall be prepared by compiling the status and action plans in each micro-watersheds, sub-basins and river basins in a hierarchical form. State Water Policy 2008 considered micro - watershed as the basic unit and the river basin as an integrated unit of micro-watersheds. Formulation of Master Plans for Municipal Corporations, Municipal Councils, Town Panchayats and Village Panchayats are progressing under the aegis of the Town and Country a Planning Department under the Local Self Government Department. Master Plans so prepared for local bodies under section 34 of the Kerala Town and Country Planning Act 2016 contain provisions for conservation of micro-watersheds and sub basins

	within the local area, regulations for natural hazard prone areas and disaster management. Harithakeralam Mission has also prepared plans for the rejuvenation of streams, ponds, lakes, etc. at the Gramapanchayat and Block Panchayat levels. **Formulation of Master Plans for major rivers in the State** Formulation of State level Master Plan for major rivers in the State is a combined effort of various stakeholder departments such as WRD, Revenue, Agriculture, LSGD etc. A holistic approach is required for the purpose and therefore, a task force comprising representatives from various stakeholder departments need to be constituted. Water Resources Department is focused on the preparation of master plans for major rivers in the State and priority will be given to those rivers that are prone to flood and passing through densely populated areas viz. Periyar, Chalakkudy, Pamba, Meenachil, Muvattupuzha, Karamana, Bharathapuzha and Chaliyar rivers. Preparatory works for formulating Master Plans for rivers have been started and Executive Engineers of Irrigation department have already been entrusted with collection of data of all the major rivers in the State in a time bound

	manner. On 02.06.2022, Chief Engineer (I&A) and Chief Engineer (IDRB) have been directed to submit an action plan for the phased formulation of Master Plans for the major rivers in the State. **UPDATED REPORT** The formulation of State Level Master Plan for major rivers in the state is a combined effort of various stakeholder departments such as WRD, Revenue, Agriculture, LSGI's, Disaster Management, etc. The draft RBCMA has been received to Government on 13.03.2024 after various levels of discussions and deliberations. Comments were submitted by other departments including KSDMA, Environment, Forest, KSEB and Revenue. A final draft incorporating the comments has been received to Government on 30.07.2024 While the institutionalisation of RBCMA is in progress, the Department is taking efforts for achieving various components of the river basin master plans, such as calculation of environmental flow, river water utilisation study, Pollution abatement study, flood forecasting studies etc. As a pilot initiative, the Integrated River Basin Management Plan for Greater Pamba

	basin (which includes Pamba, Achenkovil and Manimala) is in - progress with support from World Bank under PforR DLI-7. The first stakeholder meeting was conducted at Pathanamthitta on 17.02.2024 with participation from MPs, - MLAs, other people's representatives and Public. As part of the Kerala-Dutch co- operation in Water sector, capacity building programs have been conducted for officials from the department and other stakeholder departments. for. the preparation of River Basin Master Plans. The Flood Forecasting studies have been carried out by IDRB in Periyar and Chalakkudy river Basins. The Flood Forecasting & Integrated .Reservoir Operation studies have been carried out by IDRB in Pamba, Achenkovil and Manimala basins.
Paragraph 2.3 **Non- enactment of legislation to identify and demarcate flood plains in the State** Government of Kerala has not enacted the Flood Plain Zoning Bill proposed by	The State of Kerala had already informed the Ministry of Water Resources and Ganga Rejuvenation about the practical difficulties and limitations of enacting the Flood Plain zoning legislation in Kerala. The topography of Kerala was unique when compared with the states that had implemented the legislation. In India, only three States namely Manipur, Rajasthan and Uttarakhand had enacted the legislation as of December 2016. Kerala had

the Government of India in the year 1975. The need to prevent encroachments along rivers and flood plains was emphasised in the draft River Regulation Zone notification, 2016, under the Environment (Protection) Act, 1986 which was circulated to the States by the Ministry of Environment, Forests, and Climate change (MoEFCC). Identification and demarcation of the flood plains would enable the Government to take proactive measures in controlling potential encroachment activities in the flood plains and help the GoK in their activities on flood control. **Recommendation of C&AG** 'GoK may initiate action for a	never been considered as a major flood prone State till the flood of 2018 unlike the States located in Indo-gangetic plain. The States located on the banks of Ganges, Yamuna and Brahmaputra basins are yet to enact the Flood Plain Zoning Bill. Flood plain zoning needed institutional support and inter-departmental coordination. Though Kerala had an undulating topography and a high population density, Government recognises it is a vital tool in preventing flood. Feasibility study on enacting the Flood Plain Zoning Bill in the State will be conducted with the cooperation of various stakeholder departments. **UPDATED REPORT** As per the minutes of meeting of Permanent Expert Technical committee held on 14.03.2023, discussion was made on the new guidelines issued by MHA (Ministery of Home Affairs) regarding the flood plain zoning measures for demarcating zones Or areas likely to be affected by floods which hit with different magnitude, frequencies and probability and to specify the types of permissible developments in these zones, so that whenever floods actually occur, the damage can be minimised. Delineation

legislation/regulation on flood plain zoning, as well as constitute an Authority to identify and demarcate flood plain zones of the State and to prohibit or restrict the use of these lands'.	and demarcation of flood plain zones on certain notified stretch (es) of river(s) within the state and regulation of various activities permissible therein need to be identified and the most appropriate methodology need to be adopted for implementing the same. The critical zones of the major rivers viz. Bharathapuzha, Periyar and Pamba need to be identified for assessing the flood risk in these locations and future land use - development may be planned based on the assessment. Since the relocation of Hospitals, Schools, and other important Public Institutions, etc. is not practically viable; flood management approach may be resorted to rather than flood plain zoning in these locations. In small river basins, the flood risk assessment, identification of critical locations and delineation of flood plain zones can be realised through mass awareness programs conducted with the support of LSGI's, Disaster Management, Revenue and other stakeholder Departments. Future land use planning and development can be regulated by this means. Since this exercise is huge and requires finer inputs locally, it is required to convene a public technical conclave of stakeholders to arrive at the same, for which

	steps are being initiated.
Paragraph No.2.4 **Flood Hazard Map not conforming to criteria** Government of kerala may take steps to ensure availability of large scale flood hazard maps conforming to CWC criteria which would facilitate planning, policy making and prioritization of flood mitigation activities by identifying flood risk areas.	Peppara Dam and reservoirs are owned and operated by Kerala Water Authority. It is located on the upstream side of Karamana river in Thiruvanathapuram district. The dam has a gross storage capacity of 70 Mm3 at FRL of +110.50m. The maximum permitted storage level at present is + 107.50m (ie,52.60Mm3). A study has been conducted for flood inundation mapping and emergency response system for Peppara and Aruvikkara downstream. It is learnt that the report has been forwarded to District collector for information . Flood extend during 100 cumecs discharge , 400 cumecs discharge and 600 cumecs discharge are studied and mapped .The local body wise details of flood inundated areas are also mapped for 100 cumecs discharge, 400 cumecs discharge, and above 600 cumecs discharge.
Paragraph No. 3.1 **Adequacy of rain gauges in Periyar basin**	At the time of conducting audit, Irrigation department was maintaining ten meteorological stations with rain gauges in Periyar basin. Therefore the comment that only six rain gauges were operational is not true. After the 2018

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Periyar basin, which is having an area of 5159.71 sq. Km, is largely characterised as a hilly terrain upto Neeleswaram. As per the Bureau of Indian Standards (code IS: 4987-1994), rain gauge density at hilly areas with heavy rainfall is 1 rain gauge per 150 sq. km. Accordingly, a minimum requirement of 32 rain gauges was to be made available in Periyar basin. Now, only 6 rain gauges conforming to IMD standards were in place. Though Irrigation Department and KSEBL are maintaining rain gauges in Periyar basin, data generated by those gauge stations conforming to IMD standards is utilized by IMD. Since data from Irrigation department gauges were	floods, Government of Kerala decided to develop a full-fledged inflow forecasting and flood early warning system with real time monitoring operational in all river basins through Tipping Bucket Rain Gauges, Radar Level Sensors and Automatic Weather Stations. Out of the 99 Tipping Bucket Rain Gauges (TBRG) proposed to be installed in the river basins of Kerala under National Hydrology Project, 18 TBRGs were earmarked for Periyar basin. Proposed TBRGs have already been installed at various locations falls under the Periyar basin viz. Pattal, Thabore, North Paravoor, Vadattupara, Aluva and Neriyamangalam in Ernakulam District, Chinnar Estate, Vandiperiyar, Upputhura, Adimaly, Pallivasal, Kattappana, Vandanmedu, Nedumkandam and Kumily in Idukki District and Mathilakam in Thrissur District. Installed Tipping Bucket Rain Gauges (TBRG) have IMD specifications. Therefore, the data generated by TBRGs of Irrigation Department could be used by the IMD. Real time data generated from these rain gauges is available in the server maintained at the Integrated Command Control Centre (ICCC) at Jalavijnana Bhavan in Thiruvananthapuram. During the heavy rainfall in the months of October-November 2021, real time

not utilised by IMD, they are not being considered while assessing the adequacy of rain gauges in Periyar basin. **Recommendation of C&AG** 'Adequacy of the number of rain gauges capable of generating real time data in order to ensure accuracy of rainfall estimation may be ensured. System of sharing data from rain gauges with IMD must be put in place at the earliest'.	data from these stations have been supplied to the State Emergency Operations Centre (SEOC)/ District Emergency Operations Centre (DEOC) under Kerala State Disaster Management Authority (KSDMA) and it helped the KSDMA play an instrumental role in planning and coordinating emergency operations during this crisis period. **UPDATED REPORT** When evaluating the IMD stations using the Thiessen polygon, the "Idukki"station covers the largest area at 1774.42 km²in the basin, encompassing the Mullaperiyar and Idukki catchments, which include dense forests. This makes impractical to install rain gauges according to IS 4987:1994. While the "Aluva PWD"station covers the smallest area of191.72 km².Currently, there are ten Standard Rain Gauges (SRG) and Eighteen Tipping Bucket Rain Gauges (TBRGs) owned by the Irrigation department. Additionally, the installation of four newly proposed TBRGs is nearing completion. Therefore, the total number of rain gauges owned by the Irrigation Department will be Thirty-Two. The rain gauges effectively cover most areas in the basin in compliance with IS 4987:1994. The majority of Thiessen polygons

	encompass less than 200 km², except for the Mullaperiyar catchment. The Kumali station which is situated at the corner of the Theissen polygon covers the Mullaperiyar catchment, which extends552.8 km².Thirteen additional Automatic Rain Gauges (ARG) with Real-Time Data Acquisition Systems (RTDAS) have been installed, and efforts are underway to rectify the coverage gaps in the Mullaperiyar catchment. Rectification of these is expected soon, enabling rainfall monitoring across the Mullaperiyar catchment. The report notes that data from rain gauges operated by the Irrigation Department were not utilized by IMD and were consequently excluded from the assessment of rain gauge adequacy in the Periyar basin. It is recommended to incorporate data from these gauges to evaluate the adequacy of rain gauge coverage. Furthermore, based on outputs from the newly developed Periyar Flood Forecasting System (Periyar FEWS), the installation of an additional four rain gauges is nearing completion. Since August 31, 2022, the department started Kerala Water Resources Information System (Kerala WRIS), serving as a common platform for consolidating water related information from various departments, including data from IMD. The IMD is involved in the program

	as a stakeholder, having access to Kerala WRIS for data sharing and management.The Thiessen polygons generated from all stations owned by both the IMD and Irrigation Department effectively capture rainfall across the basin. In some areas where stations are closely located, spatial distribution may be less efficient. Most polygons typically fall within the range of 100 to 150 km^2, which complies with IS 4987:1994 standards.
Paragraph No. 3.2 **Adequacy of flow gauge density in Periyar basin** Five flow gauges were installed in the Periyar basin by CWC and the Irrigation Department, of which three gauges at Kalady, Mangalapuzha and Marthandavarma are maintained by the Irrigation Department and the other two gauges at Neeleswaram and Vandiperiyar are maintained by the	In accordance with the World Meteorological Organisation 2008 norms, there is a requirement of three (3) inflow gauges for the 5159.71 sq. km Periyar basin (one flow gauge per 1875 sq. km). At present, there are 5 inflow gauges in Periyar basin and the audit admitted that the inflow gauge density is adequate as a whole. With respect to the audit observation that the free Periyar catchment, comprising of 2367.22 sq.km of hilly terrain needs an additional flow gauge to be located just upstream of Bhoothathankettu barrage, it is to be noted that the Irrigation department set up an additional four Radar Level Sensors (three under NHP and one under DRIP) in Periyar basin at 1) Malayattoor Kodanad bridge 2) Neriamangalam 3) Purappallikavu and 4) Bhoothathankettu. Real time data generated from these RLSs are

CWC. Even though, the existing number of flow gauges in the basin as a whole was adequate, there is a shortfall of one flow gauge in the free Periyar catchment, comprising of 2367.22 sq.km of hilly terrain (as per World Mateorological Organisation 2008 norms, one flow gauge per 1875 sq. km is needed in hilly terrain). An additional flow gauge needs to be located just upstream of Bhoothathankettu barrage, which is a major control point in the periyar basin.	available in the server maintained at the Integrated Command Control Centre (ICCC) at Jalavijnana Bhavan in Thiruvananthapuram. **UPDATED REPORT** The report highlights that the existing number of river gauges in the basin is considered adequate. There are a total of eight river level monitoring stations in Periyar including the one owned by the CWc as well the Irrigation Department. Furthermore, based on the outputs from the recently developed Periyar Flood Forecasting System (Periyar FEWS), the installation of six additional automatic river level gauges is nearing completion. Real-time level monitoring stations have been installed at various reaches to accurately estimate inflows from different catchments. The newly proposed river monitoring stations will provide precise estimates of inflow from catchments across different river reaches. Additionally, a station has been established at the Bhoothathankettu Barrage, and another one in the reach extending to the Pooyamkutty area. These ensures capture of runoff volumes from catchments that contribute significant volumes of runoff during high storms.
Paragraph 3.3	Even though the list of reservoirs which requires inflow forecasting stations

Flood forecasting stations not set up in the State Central Water Commission requested (October 2011) Government of Kerala to provide list of reservoirs which required inflow forecasting stations and list of cities/towns for flood forecasting purpose. CWC confirmed (August 2019) to Audit that the State failed to furnish the details and hence no Flood Forecast Stations (FFS) were set up by the CWC in the State prior to flood of 2018. This was despite 275 flood forecasting stations having been set up by CWC across the country by the year 2017. The failure of GoK to provide list of reservoirs and cities/towns to CWC	and list of cities/towns for flood forecasting purpose was not formally submitted to the Central Water Commission, a lot of discussions with regard to the efficacy of flood forecasting systems suitable for the State had been held with CWC. In the spirit of the discussions, the Government have had with the CWC, it was decided to install 8 Tipping Bucket Rain Gauges, 18 Radar Level Sensors and 19 Automatic Weather Stations in various river basins for the purpose of real time flood forecasting in 2014. The work was awarded to the contractor in April 2014 at a cost of Rs.1.34 crore. Most of these flood forecasting machineries were installed prior to the flood of 2018. Therefore, it is not true to say that the State of Kerala was not concerned over the setting up of flood forecasting stations in flood prone basins prior to the flood of 2018. Chief Engineer, Irrigation & Administration, on 17.04.2021 has formally forwarded the list of flood prone cities/ towns in the State that require flood forecasting stations and also the list of reservoirs, which need inflow forecasting. In light of the calamitous 2018 floods, Government of Kerala had

resulted in non-installation of FFS in the State and resultant deprival of data which State could have utilised for flood forecasting purpose.	strengthened the inflow forecasting and flood early warning system in the State by setting up more Tipping Bucket Rain Gauges, Radar Level Sensors and Automatic Weather Stations. The work for installing the devices was awarded to the contractor at a cost of Rs. 10, 92,96,320/- on 27.01.2020. Out of a total of 168 flood early warning systems purchased already, 97 Tipping Bucket Rain Gauges, 46 Radar Level Sensors and 12 Automatic Weather Stations were installed. Remaining 13 equipments will soon be installed. **UPDATED REPORT** The Central Water Commission (CWC) currently operates inflow forecasting points at Idukki and Idamalayar Dams, and Neeleswaram. Concurrently, the Irrigation department manages the Periyar Flood and Early Warning System (Periyar FEWS), developed under the National Hydrology Project. This web-based system provides inflow forecasting for reservoirs and selected points within the Periyar basin. The precipitation forecasts at various spatial and temporal resolution to predict extreme precipitation at short (1-3 day) to longer (7 day) lead times is translated to flood inflow forecasts through hydrological modelling, which

	forms an integral component of the Periyar Flood Forecasting and Early Warning System. The key outputs are given below with the respective lead times:Inflow forecast at Reservoirs in the basin ◆ Forecast sources: IMD (up to 7 days lead, first 3 days-IMD WRF and remaining 4 days-IMD GFS), IMD Ensemble (7 days lead) and IBM Graf (7 days lead) ◆ The system runs an integrated hydrologic model, the US Army Corps' HEC-HMS Model, to predict the inflow The forecasted inflow into Reservoirs can be supplied and will be more beneficial for informed action with a longer lead time, rather than real time data acquisition system products, considering the geomorphology of the basin.
Paragraph 3.4 **Non- completion of a project intended for obtaining data required for flood management** Irrigation department awarded the work	In the year 2014, Government of Kerala decided to set up a real time flood forecasting system by installing 8 Tipping Bucket Rain Gauges, 18 Raldar Level Sensors and 19 Automatic Weather Stations in various river basins. The work was awarded to the contractor, M/s Astra Microwave Products Ltd on 26th April 2014 at a cost of 1,37,97,337/-. The contractor was bound to

for installing a Real Time Data Acquisition System to M/s Astra Microwave Products Ltd. Hyderabad in April 2014 at a cost of Rs. 1.34 crore. Many of the equipment installed by the firm are not functional. Though more than five years have elapsed, the objective of obtaining real time hydrological data useful for improving flood management capabilities remained unachieved.	complete the installation of the system by 25.07.2014. Since data generated from some of these devices were found to be erroneous and the firm failed to fulfil their obligations to rectify the defects within the time limit or the extended period, action has been initiated against M/s Astra Microwave Products Ltd. for breach of the agreement conditions. Accordingly, Superintending Engineer, Field Studies Circle, Thrissur (agreement authority) terminated the contract of the firm vide proceedings dated 28.12.2021. On 30.12.2021, the agreement authority directed the Contractor to pay an amount of Rs. 62,04,749/- within three months, towards tentative liability as per relevant clause of Kerala PWD manual. **UPDATED REPORT** The Chief Engineer has initiated steps to blacklist the firm due to breach of agreement conditions. Installation of RTDAS systems including TBRG and automatic level sensor under the National Hydrology Project (NHP) is awarded to a new contractor. Installation of instruments is currently underway, with ongoing rectifications
Paragraph No. 3.6	Peppara Dam and reservoirs are owned and operated by Kerala Water

Assement of impact of dam spilling on flooding in downstream areas In view of the Possible loss active storage volume of dams through sedimentation and it is consequential adverse impact on flood control, KSEB and Irrigation department may ensure that sedimentation studies as prescribed in reservoir operation guidelines issued by Bureau of Indian standards are conducted and timely action taken to arrest the capacity loss of rivers.	Authority. It is located on the upstream side of Karamana river in Thiruvanathapuram district. The dam has a gross storage capacity of 70 Mm3 at FRL of +110.50m. The maximum permitted storage level at present Is + 107.50m (ie,52.60Mm3) . The flood wave arrival timings were also analysed. The first flood wave arrival time and the time for maximum inflow are also analysed in the study. The Panchayath wise flood extend above 600 cumecs discharge were also mapped. In the Report of the Comptroller and Auditor General of India (Report No. 6 of the year 2021) on Preparedness and response to flood in Kerala, Chapter -III-Flood Forecasting and reservoir Operation", paragraph No 3.6-Assessment of Impact of Dam spillage on Flooding in Downstream area, is regarding the evaluation of relative contributions of the spills of Idamalayar Dam and Idukki Dam to the flood observed at Neeleswaram Gauge Station (Periyar River Basin) and also the contribution of Spills from Mullaperiyar Dam to Idukki inflows. Further in the report, it is stated that the operation of the Mullaperiyar had

	a negligible effect on 14 August 2018, but its contribution to the inflows at Idukki was significant during 15th to 18th August (>20 %), considering the magnitude of the floods. It is further stated that, Government in its response stated (September 2020) that contribuuion of Mullaperivar dam to the inflows of Idukki during the period of severe Hoods from 15-18 August 2018 was very significant. Since sudden and unexpected releases from Mullaperiyar dam by Tamil Nadu Government was expected any moment without notice and the quantum of inflow to Idukki reservoir was not known in advance, KSEBL had to provide sufficient flood cushion to ensure safety of the dam as well as controlled release. But for sudden release of 169.97 MCM of water from the Mullaperiyar during the extreme flood days, the attenuation of downstream flood would have been more significant. The report suggest that, the departmental response indicates the need to prioritise and have in place an integrated reservoir management plan, particularly in multi dam basins. This is significant both because i) the control of reservoir/ dam operations

	in the State is distributed among KSEBL and the Irrigation Department and ii) there is the likely impact of spills from dams under the control of one state in the downstream reservoirs and rivers of another state. As the first two recommendations being related with the Idamalayar dam and Idukki dam, operated and maintained by KSEBL, the Power Department in Government and CMD, KSEBL were requested to furnish RMT on these recommendations. **Action Taken Report on Rule Curve of Mullaperiyar dam (Recommendation 3.5(c))** 1. The Hon' ble Supreme Court upon hearing the Counsels on 16.03.2021 in this matter, directed the State of Tamil Nadu to furnish requisite information on Rule Curve, Gate Operation Schedule and Instrumentation plan to the Supervisory Committee within two weeks from the date of order. The Supervisory Committee was directed to take necessary steps including to issue appropriate directions to the concerned/party States, as may be necessary and to submit action taken report before the Court and compliance regarding finalization of the

	three issues Rule Curve, Gate Operation Schedule and Instrumentation of dam. 2. The Rule Curve, Gate Operation Schedule & Note on Instrumentation of dam prepared by Tamil Nadu was furnished from CWC to the Additional Chief Secretary, Water Resources Department, Government of Kerala vide e-mail letter dated 26.03.2021 for the remarks. 3. The State of Kerala submitted final remarks on Rule Curves, Gate Operation Schedule and Instrumentation plan of Mullaperiyar Dam vide letter dated, 25.06.2021 of the Additional Chief Secretary, Water Resources Department. 4. Central Water Commission .conducted a virtual meeting for discussion on final, remarks submitted by Government of Kerala and finalization of Rule Curve of Mullaperiyar dam on 09.07.2021 with the officers of Government of Kerala. Government of Tamil Nadu and KSEBI. In the meeting. Kerala presented its analysis, views and comments on the rule curve for the Mullaperiyar Dam proposed by the Government of Tamil Nadu. Kerala specifically objected to the proposal in the Upper rule

curve put forward by Tamil Nadu to maintain the water Jevel in the reservoir at 142 ft (the upper rule level) on September 20th and November 30th in the, backdrop of the recent floods experienced in Mullaperiyar catchment in recent years. The meeting concluded with the suggestion of the CWC to the Government of Kerala to prepare a new rule curve for the Mullaperiyar Dam.

5. In view of the above-mentioned meeting, the Government of Kerala submitted the Revised Rule Curve of Mullaperiyar dam vide letter dated 22.07.2021 of the Chief Engineer, ISW.
6. CWC furnished its comments on Rule Curve submitted by Government of Kerala vide letter dated 28.07.2021.
7. Government of Kerala submitted Detailed Technical Report on Rule Curve of Mullaperiyar dam to CWC vide letter dated 18.09.2021 of the Additional Chief Secretary, Water Resources Department.
8. Government of Kerala submitted its observations on Rule Curve prepared by Government of Tamil Nadu in consultation with CWC and further requested that Rule Curve prepared and concerns raised by

	Government of Kerala may be brought to the notice of the Hon'ble Supreme Court vide D.O Letter dated 18.09.2021 of the Additional Chief Secretary, Water Resources Department. 9. The Chairman, Supervisory Committee & Chief Engineer, DSO, vide letter dated 04.10.2021, has submitted clarification on the observations of Government of Kerala on Rule Curve of Mullaperiyar dam. 10. The Status report in compliance with order dated 16.03.2021 on behalf of Respondents 3 & 4 (CWC & Chairman, Supervisory Committee) was filed in the, Hon'ble Supreme Court on 14.10.2021. These respondents have recommended the Hon'ble Court for the acceptance of the Rule Curve of Mullaperiyar dam prepared by Tamil Nadu in consultation with CWC without taking into account any of the concerns raised by the Government of Kerala. 11. The Hon'ble Supreme Court in its order dated 28.10.2021 had directed the State of Kerala to file an affidavit, especially to deal with the issue on Rule Curve and about the current approach on or before 08.11.2021.

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	12. The State of Kerala filed a reply affidavit to the Status report filed by the respondents 3 and 4 on 08.11.2021. furnishing climate changes and the erratic, rainfall experienced in Kerala during the last 4 years since 2018 especially in the Idukki district, objections of State of Kerala on the Upper Rule curve formulated by Tamil Nadu, and need for the comprehensive instrumentation plan including the seismic instrumentation plan for Mullaperiyar dam. Kerala has prayed before the Hon'ble Court to consider the concems of Kerala on fixing the Upper Rule Curve of; Mullaperiyar dam and to reconsider the Upper Rule Curve formulated by Tamil Nadu. 13. Vide D.O. Letter No ISWC1/76/2021-WRD Dated 28.11.2022, the Secretary Gok had furnished specific remarks on the points [a)Shape of Rule Levels b)Prominent .Monsoon Seasons c) Two Peaks] raised by CWC on Rule Curve. 14. During the 16th Supervisory Committee held on 27-3-2023 at Kumily, the reply to the above letter was handed over to Kerala by the officials of CWC, where in it is stated that all the concems of Kerala

has been examined by CWC and the observations has been forwarded to Kerala and the present one is also similar and have furnished observation again.

Present Status

The matter is sub-judice, as no final decision has been issued by the Hon 'ble Supreme Court. In the mean time the initial Rule Curve submitted by Tamil Nadu and approved by CWC, is followed.

Upper Rule Levels (Minimum 50% chance of filling the reservoir up to 142ft)

Date	Upper Rule Level for morderation of flood as well as ensuring filing of upto 142ft with 50% probability (ft)
10 June	136.00
20 June	136.00
30 June	136.00
10 July	136.30
20 July	136.60
31 July	137.00

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	10 August: 137.50 20 August: 138.40 31 August: 139.80 10 September: 140.90 20 September: 142.00 30 September: 140.00 10 October: 138.50 20 October: 137.75 31 October: 138.00 10 November: 139.50 20 November: 141.00 30 November: 142.00
Paragraph No. 3.7 **Siltation of dams and reduction in storage capacity** Siltation study was conducted in all the reservoirs under the control of WRD. Though sanction was accorded in	**Status of desiltation of dams under Water Resources Department** **Mangalam dam** Desiltation of Mangalam dam is a three yearlong project and was started on 17.12.2020. As of 19.04.2022, 133673 CUM sediments (5%) removed out of a total estimated quantity of 2.95 MCM. **Malankara dam**

September 2017 by GOK for de-siltation of Mangalam and Chuliyar dams, the works are yet to commence as of November 2019. **Recommendation of C&AG** 'In view of the possible loss of active storage volume of dams through sedimentation and its consequential adverse impact on flood control, KSEB and Irrigation Department may ensure that sedimentation studies as prescribed in Reservoir Operation Guidelines issued by Bureau of Indian Standards are conducted and timely action taken to arrest the capacity loss of reservoirs'.	KERI, Peechi conducted a bathymetric survey in 2020-21 in connection with the distillation of Malankara Dam. Steps are being taken by the Chief Engineer, Irrigation and Administration to invite expression of interest for preparation of a detailed project report for removal of soil and silt from Malankara Dam. **Malampuzha dam** As per the decision dated 04-12-2020 of the 9th High Level Empowered Committee on desiltation, the Government has given permission to call for expression of interest (EOI) for the desiltation of Malampuzha Dam. **Karappuzha dam** According to a bathymetric survey conducted by KERI, Peechi in February 2021, the storage capacity of the Karappuzha Reservoir was found to be decreased by 12.56%. Steps are being taken for inviting EOI. **Kanjirappuzha dam** According to a bathymetric survey conducted by the Kerala Engineering Research Institute in 2020, the storage capacity of the Kanjirapuzha dam was found to be reduced from 68.533 MM3 to 51.609 MM3. Steps are being

	taken for inviting EOI. **Chulliyar dam** Government vide G.O (Rt) No. 21/2021/WRD dated 07.01.2021 have accorded sanction for awarding desilation work of Chulliyar dam to Kerala Irrigation Infrastructure Development Corporation (KIIDC) on turn-key basis. **Walayar and Meenkara Dams** Vide G.O (Rt) No. 22/2021/WRD dated 07.01.2021, desiltation work of Walayar and Meenkara dams was awarded to Kerala State Mineral Development Corporation Ltd. (KEMDEL) on turnkey basis. **Aruvikkara dam** As per G.O (Ms) No. 1/2020/WRD dated 06.01.2020, administrative sanction was accorded for the desiltation of Aruvikkara dam and the Kerala Water Authoiry was authorised to invite Expression of Interest (EoI). The work of desiltation will be started without delay upon awarding the work to a qualified bidder. State of Kerala has now launched a project named as Operation Vahini to

	clean and deepen all the major rivers and its tributaries, streams and canals by removing silt and the objects that hinders the smooth flow of water to prevent flood events in future. The project is going ahead successfully. **UPDATED REPORT** • Asper the recommendations of Empowered Committee of desiltation of reservoirs, headed by Chief Secretary. A Standard Operating Procedure (SOP) for desiltation of Reservoirs in Kerala has Approved vide. G.O.(Ms)No.79/2017/WRD dated 26/09/2017 and as modified by vide.G.0.(Ms)No.14/2019/WRD dated 14/05/2019. Present Status of desiliation of dams under Water Resources Department. **Mangalam dam** • Desiltation of Mangalam dam was started on 17.12.2020.(As a completion period of three year). • As on 29.04.2022, 155830 CUM sediments (5.3%) was removed out of a total estimated quantity of 2950000 CUM. • Due to slow progress of Desilltation and remittance of amount to

	Government, the Empowered Committee directed to terminate the agreement of work. • The Company filed a writ petition to National Company Law Tribunal (NCLT) and obtained a stay order against the termination decision. • The case is in progress. **Malnkara Dam** • KERI, Peechi conducted a bathymetric survey in 2020-21 in connection with the Distilfation of Malankara Dam. • Based on the study a Detailed Project Report (DPR) for desiltation of Malankara Dam was prepared. • DPR placed before the 14th meeting of Empowered Committee held on 28/06/2024. • The Empowered Committee directed to examine the DPR in detail and to receive the remarks from Chief Technical Examiner (CTE). • The Chief Engineer, Project II has submitted the DPR and details to Water Resources Department for obtaining the remarks/ recommendations from CTE.

	• The sedimentation study of dams was conducted by KERI. Peechi. **Chulliyar dam** • Government vide G.O (Rt)No.21/2021/WRD dated 07.01.2021, in principle approval was accorded for awarding Desiltation work of Chulliyar dam to Kerala Irrigation Infrastructure Development Corporation (KHDC) as turn key basis. • Desiltation works at Chulliyar dam completed up to 59%. • The work is progressing. **Walayar and Meenkara Dam** • Government vide G.O (Rt)No.22/2021/WRD dated: 07.01.2021 in principle approval was accorded for awarding Desiltation work of Walayar and Meenkara Dam to Kerala State Mineral Development Corporation as turn key basis. • Desiltation works at Meenkara dam was completed up to53.56 % and • Walayar dam was completed up to30%. • The works are progressing. **Aruvikkara Dam**

	• As per G.O(Rt)No.853/2022/WRD dtd:22/09/2022, In Principle Approval was accorded for the Desiltation of Aruvikkara Dam to KIIDC through departmental execution. KIIDC had completed the survey work. • The work for Desiltation of Aruvikkara dam was tendered on 21/02/2024. • Two bidders were submitted their quotes. • The pre qualification evaluation is in progress.
Paragraph No. 4.4 **Obstruction of flood discharge through Thottappally spillway** Flood discharge through the TSW was considerably reduced due to the accumulation of mineral sand and due to the trees planted inside the mouth of the estuary. **Recommendation of C&AG**	Length of the leading channel of the Thottappally spillway right from the spillway to the sea mouth is 800m and it has a width of 380m. Due to the accumulation of mineral sand in the downstream of the spillway and the trees planted inside the sea mouth by the Social Forestry Department, width had been reduced from 380m to 150m. **Status of removal of trees at sea mouth** Since it was observed that the trees planted inside the estuary were impeding the flow of floodwaters through the spillway, the State Government have decided to remove the entire trees planted inside the estuary. Accordingly,

'Government may, prioritise works such as deepening of the leading channel upstream of TSW and timely breaking of developing sand bar, if any, at the sea mouth so as to ensure unhindered flow of flood waters to the sea, giving due consideration to extant environment related instructions while so doing'.	trees as a whole, which were planted within the 380m width of the downstream were cut down by the district administration, Alappuzha on 22nd May 2020. As part of the mission, 550 casuarina trees, which were numbered in the year 2018 and reckoned to be obstructing the flow of floodwaters were removed. As a result width was extended to a further 230m thereby reaching the required width of 380m. **Status of removal of mineral sand from downstream of the spillway** With a view to deepen and widen the estuary, Irrigation Department started removal of mineral sand from pozhi mouth and downstream of the spillway on 20.05.2020. Accordingly, an estimated quantity of 242831 cub.m sand was dredged; out of which a quantity of 175319 cub.m sand was transported to KMML. Dredging works came to a close on 22.07.2020. Through the two month long dredging mission, spillway channel was deepened and width was widened to 380m. Within a few months after completing the dredging, a sand bar was formed occupying a width of 75 m at the pozhy mouth. Accumulation of sand at the pozhi mouth is rampant. In 2021 also, dredging of sand was carried out in the downstream. An estimated quantity of around 2,49,000 cu. m. sand was dredged

	out and the exercise was completed on 27.08.2021. Government had prioritised the work of breaking down the sand bar at the pozhy mouth and is being carried out timely and periodically. There is an erratic observation in the audit report that the width of the leading channel of the TSW in the upstream side of the spillway from Thottappally to Veeyapuram is only 80 m against the required width of 365 m. The leading channel of the TSW has a length of 11 km from Thottappally to Veeyapuram. In the upstream side of the spillway, there is no such directive to maintain a width of 365 m along the 11 km stretch. In the upstream it has a variable width averaging to 100 m. The banks on both sides are heavily populated. Any change in width requires the people living on the banks to be rehabilitated. With regard to the downstream of the spillway, which has a length of 800 m, it has been prescribed to maintain a width of 380 m. The prescribed width has been maintained by the Irrigation department by cutting the trees planted inside the estuary and by removing the mineral sand. A new service/scheme was started in 2022-23 financial year for ensuring the smooth flow of flood waters from Manimala, Achenkovil and Pamba rivers by deepening the 11 Km stretch of the leading channel of Thottappally spillway.

	Funds provided for this scheme during the current financial year (2022-23) was 5 crore. Presently, works for dredging the upstream portion of the spillway is ongoing and 16.5% of works has been completed as of 31.03.2022. Besides, Government as per G.O (Rt) No. 360/2021/WRD dated 09.07.2021 have accorded administrative sanction for protecting either banks of the leading channel at an estimated cost of Rs.70.3 crore. **UPDATED REPORT** Government as per G.O (Rt) No.360/2021/WRD dated: 09/07/2021 have accorded Administrative Sanction for two works tor protecting either banks of the leading channel at an estimated cost of Rs.70.3 Crore. These two works are in progress . Also, Government as per G.O(Rt)No.240/2024/WRD, dated: 14/03/2024 have accorded Administrative Sanction for two works for protection of either banks of leading channel at an estimated cost of Rs.5 Crore. The agreement for both works have been executed.
Paragraph No. 5.2 **Execution of immediate restoration activities in post flood scenario** WRD was sanctioned Rs.536.27 crore in	Funds to the tune of Rs. 536.27 crore have been provided to the Irrigation Department from SDRF for the immediate repair and restoration of damaged infrastructure during 2018 flood. As of 18.03.2022, agreements have been executed for 97.94% of works and 91.09 % of works have

2019 for immediate repair and restoration of damaged infrastructure during 2018 flood. As of January 2020, only 20% of the works was seen completed. **Recommendation of C&AG** 'Government may put in place a system of periodic monitoring of status of works of immediate nature funded by SDRF to ensure that works sanctioned are completed on priority basis, given the State's increasing vulnerability to severe flooding events'.	already been completed. **UPDATED REPORT** Funds to the tune of Rs. 536.27 crore have been provided to the Irrigation Department from SDRF for the immediate repair and restoration of damaged infrastructure during 2018 flood. Under SDRF scheme agreement has been executed for 7065 number of works, Out of this 6984 works were completed, ie 98.85%. SDRF works will not be taken up further .

SAJI KUMAR J.
Special Secretary
Water Resources Dept.
Secretariat
Thiruvananthapuram

GOVERNMENT OF KERALA

WATER RESOURCES(ISWC) DEPARTMENT

REMEDIAL MEASURES TAKEN ON THE REPORT OF THE COMPTROLLER AND AUDITOR GENERAL OF INDIA (REPORT NO.6 of 2021) ON PREPAREDNESS AND RESPONSE TO FLOODS IN KERALA

Para No.	Remedial Measures Taken
3.6 Assessment of dam spillage on flooding in downstream area **Recommendation 3.5** *a) KSEB may ensure flood release operations for reservoirs are based on approved rule curves which further need to be regularly reviewed and updated.* *b) KSEB may conduct simulation or other studies to ensure that the approved rule curves of 2020 for Idukki and Idamalayar would be*	In the Report of the Comptroller and Auditor General of India (Report No. 6 of the year 2021) on Preparedness and response to flood in Kerala, Chapter -III-Flood Forecasting and reservoir Operation", paragraph No 3.6-Assessment of Impact of Dam spillage on Flooding in Downstream area, is regarding the evaluation of relative contributions of the spills of Idamalayar Dam and Idukki Dam to the flood observed at Neeleswaram Gauge Station (Periyar River Basin) and also the contribution of Spills from Mullaperiyar Dam to Idukki inflows. Further in the report, it is stated that the operation of the Mullaperiyar had a negligible effect on 14th August 2018, but its contribution to the inflows at Idukki was significant during 15th to 18th August (>20 %), considering the magnitude of the floods. It is further stated that, Government in its response stated (September 2020) that contribution of Mullaperiyar dam to the inflows of Idukki during the period of severe floods from 15-18 August 2018 was very significant. Since sudden and unexpected

adequate to handle situations similar to the extreme rainfall event of 2018, without consequential flooding. *c) Feasibility of putting in place rule curves based on integrated operation of reservoirs within an approved time frame must also be considered.*	releases from Mullaperiyar dam by Tamil Nadu Government was expected any moment without notice and the quantum of inflow to Idukki reservoir was not known in advance, KSEBL had to provide sufficient flood cushion to ensure safety of the dam as well as controlled release. But for sudden release of 169.97 MCM of water from the Mullaperiyar during the extreme flood days, the attenuation of downstream flood would have been more significant. The report suggest that, the departmental response indicates the need to prioritise and have in place an integrated reservoir management plan, particularly in multi dam basins. This is significant both because i) the control of reservoir/ dam operations in the state is distributed among KSEBL and the Irrigation Department and ii) there is the likely impact of spills from dams under the control of one state in the downstream reservoirs and rivers of another state. As the first two recommendations being related with the Idamalayar dam and Idukki dam, operated and maintained by KSEBL, the Power Department in Government and CMD, KSEBL were requested to furnish RMT on these recommendations, vide Government letter No.ISWC1/141/2019-WRD dated 19/07/2024. **<u>Action Taken Report on Rule Curve of Mullaperiyar dam (Recommendation 3.5(c))</u>** 1. The Hon'ble Supreme Court upon hearing the Counsels on 16.03.2021 in this matter,

directed the State of Tamil Nadu to furnish requisite information on Rule Curve, Gate Operation Schedule and Instrumentation plan to the Supervisory Committee within two weeks from the date of order. The Supervisory Committee was directed to take necessary steps including to issue appropriate directions to the concerned/party States, as may be necessary and to submit action taken report before the Court and compliance regarding finalization of the three issues Rule Curve, Gate Operation Schedule and Instrumentation of dam.

2. The Rule Curve, Gate Operation Schedule & Note on Instrumentation of dam prepared by Tamil Nadu was furnished from CWC to the Additional Chief Secretary, Water Resources Department, Government of Kerala vide e-mail letter dated 26.03.2021 for the remarks.

3. The State of Kerala submitted final remarks on Rule Curves, Gate Operation Schedule and Instrumentation plan of Mullaperiyar Dam vide letter dated 25.06.2021 of the Additional Chief Secretary, Water Resources Department.

4. Central Water Commission conducted a virtual meeting for discussion on final remarks submitted by Government of Kerala and finalization of Rule Curve of Mullaperiyar dam on 09.07.2021 with the officers of Government of Kerala, Government of Tamil Nadu and KSEBL. In the meeting, Kerala presented its

analysis, views and comments on the rule curve for the Mullaperiyar Dam proposed by the Government of Tamil Nadu. Kerala specifically objected to the proposal in the Upper rule curve put forward by Tamil Nadu to maintain the water level in the reservoir at 142 ft (the upper rule level) on September 20th and November 30th in the backdrop of the recent floods experienced in Mullaperiyar catchment in recent years. The meeting concluded with the suggestion of the CWC to the Government of Kerala to prepare a new rule curve for the Mullaperiyar Dam.

5. In view of the above-mentioned meeting, the Government of Kerala submitted the Revised Rule Curve of Mullaperiyar dam vide letter dated 22.07.2021 of the Chief Engineer, ISW.

6. CWC furnished its comments on Rule Curve submitted by Government of Kerala vide letter dated 28.07.2021.

7. Government of Kerala submitted Detailed Technical Report on Rule Curve of Mullaperiyar dam to CWC vide letter dated 18.09.2021 of the Additional Chief Secretary, Water Resources Department.

8. Government of Kerala submitted its observations on Rule Curve prepared by Government of Tamil Nadu in consultation with CWC and further requested that Rule Curve prepared and concerns raised by Government of Kerala may be brought

to the notice of the Hon'ble Supreme Court vide D.O Letter dated 18.09.2021 of the Additional Chief Secretary, Water Resources Department.

9. The Chairman, Supervisory Committee & Chief Engineer, DSO, vide letter dated 04.10.2021, has submitted clarification on the observations of Government of Kerala on Rule Curve of Mullaperiyar dam.

10. The Status report in compliance with order dated 16.03.2021 on behalf of Respondents 3 & 4 (CWC & Chairman, Supervisory Committee) was filed in the Hon'ble Supreme Court on 14.10.2021. These respondents have recommended the Hon'ble Court for the acceptance of the Rule Curve of Mullaperiyar dam prepared by Tamil Nadu in consultation with CWC without taking into account any of the concerns raised by the Government of Kerala.

11. The Hon'ble Supreme Court in its order dated 28.10.2021 had directed the State of Kerala to file an affidavit, especially to deal with the issue on Rule Curve and about the current approach on or before 08.11.2021.

12. The State of Kerala filed a reply affidavit to the Status report filed by the respondents 3 and 4 on 08.11.2021, furnishing climate changes and the erratic rainfall experienced in Kerala during the last 4 years since 2018 especially in the Idukki district, objections of State of Kerala on the Upper Rule curve formulated by

Tamil Nadu, and need for the comprehensive instrumentation plan including the seismic instrumentation plan for Mullaperiyar dam. Kerala has prayed before the Hon'ble Court to consider the concerns of Kerala on fixing the Upper Rule Curve of Mullaperiyar dam and to reconsider the Upper Rule Curve formulated by Tamil Nadu.

13. Vide D.O. Letter No ISWC1/76/2021-WRD Dated 28.11.2022, the Secretary ,GoK had furnished specific remarks on the points [a)Shape of Rule Levels b)Prominent Monsoon Seasons c) Two Peaks] raised by CWC on Rule Curve.

14. During the 16th Supervisory Committee held on 27-3-2023 at Kumily, the reply to the above letter was handed over to Kerala by the officials of CWC [D.O Lr NoT-119/2/2022-DSM DTE Dated 8.2.2023/87-92] where in it is stated that all the concerns of Kerala has been examined by CWC and the observations has been forwarded to Kerala and the present one is also similar and have furnished observation again.

Present Status

The matter is sub-judice, as no final decision has been issued by the Hon'ble Supreme Court. In the mean time the initial Rule Curve submitted by Tamil Nadu and approved by CWC, is followed.

Upper Rule Levels (Minimum 50% chance of filling the reservoir up to 142 ft)

Date	Upper Rule Level for moderation of flood as well as ensuring filling of reservoir upto 142 ft with 50% probability (ft)
10 June	136.00
20 June	136.00
30 June	136.00
10 July	136.30
20 July	136.60
31 July	137.00
10 August	137.50
20 August	138.40
31 August	139.20
10 September	140.00
20 September	142.00
30 September	140.00
10 October	138.80
20 October	137.75
31 October	138.00
10 November	139.50
20 November	141.00
30 November	142.00

G. SUKUMARAN NAIR
Joint Secretary to Govt.
Water Resources Dept.
Govt. Secretariat, Thiruvananthapuram

Annexure III

Appendices from AG's Report

Appendix 1.1

Statement showing list of institutions covered by Audit

(Reference: Paragraph 1.4)

Sl. No.	Name of District	Name of institutions covered by Audit
1.	Alappuzha	District Disaster Management Authority, District Emergency Operations Centre, Chengannur Taluk, Kuttanad Taluk, Major Irrigation Division, Minor Irrigation Division, Mechanical Division, Chief Engineer Kuttanad Package, Kuttanad Development Division Thanneermukkom, Fire Stations at Thakazhi and Chengannur
2.	Ernakulam	District Disaster Management Authority, District Emergency Operations Centre, Aluva Taluk, Paravur Taluk, Office of the Special Tahsildar, Nedumbassery, Village Office, Nedumbassery, Major Irrigation Division, Minor Irrigation Division, Fire stations at Aluva and North Paravur, Idamalayar dam, Bhoothathankettu barrage, Central Water Commission Regional Office
3.	Idukki	District Disaster Management Authority, District Emergency Operations Centre, Idukki Taluk, Devikulam Taluk, Major Irrigation Division, Minor Irrigation Division, Idukki dam, Lower Periyar dam, Madupetty dam, Kallarkutty dam, Fire Stations
4.	Thrissur	District Disaster Management Authority, District Emergency Operations Centre, Chalakkudy Taluk, Thalappilly Taluk, Major Irrigation Division, Minor Irrigation Division, Vazhani Dam, Poringalkuthu Dam, Lower Sholayar Dam, Civil Defence Training Institute, Fire and Rescue Services Academy
5.	Thiruvananthapuram	Revenue Disaster Management Department, Water Resources (Irrigation) Department, Finance Department, Transport Department, Kerala State Disaster Management Authority, State Emergency Operations Centre, India Meteorological Department, Fire and Rescue Headquarters, Chief Engineer Irrigation, Design and Research Board, Chief Engineer Irrigation and Administration, Chief Engineer Mechanical, Chief Engineer Project II, Institute of Land and Disaster Management, Dam Safety Organisation, Kerala State Electricity Board Limited, Land Use Board, Commissionerate of Land Revenue
6.	Dam Safety Organisation of KSEBL, Pallom, Kottayam district	

Appendix 2.1

Details of encroachment of water bodies noticed in the test-checked districts and status of action taken by Departments*

(Reference: Paragraphs 2.1, 2.3, 4.1)

Sl. No.	Location details	Number of encroachments	Extent of land (in Ha)	Whether complaints received or not
1.	**Deviyarpuzha at Adimali-Valara stretch (Survey no. 205 and 206) in Idukki district**	23	0.2221	8 nos. from 2013 to 2016
Performance Audit Party examined 11 files relating to the encroachment of Deviyarpuzha maintained at Taluk Office, Devikulam. All these files pertained to the complaints of local people and departments regarding illegal construction of buildings by encroachment of the river bed and obstructing the free flow of the river. However, no action was taken to identify the extent of encroachment by surveying the area. Superintendent of Police (Intelligence), Special Branch CID, Thiruvananthapuram reported (December 2012) to the District Collector, Idukki about encroachments of Deviyarpuzha by constructing multi-storied buildings and warned that non-eviction of these encroachments would lead to further encroachments of the area. In one case, Village Officer, Mannamkandam Village after conducting preliminary enquiry reported (January 2015) that there were 23 number of encroachments (0.2221 ha) of Deviyarpuzha at Adimali-Valara stretch near Irumbupalam. The encroachers had been occupying the land for more than five years. No further action was taken in this regard. A joint site verification (December 2019) revealed that the riverbank was encroached upon by constructing huge buildings which reduced the width of the river to a narrow stretch and thereby obstructed the free flow of the river which caused inundation of adjacent area in 2018 flood. No survey of the river to demarcate the boundaries was conducted to identify and evict the encroachers. Taluk Officer, Devikulam Taluk replied that out of 53 complaints and KLC cases regarding the encroachment of rivers and water bodies received in Devikulam Taluk upto 2018-19, only one eviction has taken place till date. Other cases were pending in the office either with the surveyor or with the village officer.				
2.	**Kanoli Canal in Thrissur district**	832	17.97	Yes in May 2008
Kanoli Canal is part of west coast canal network of Kerala and the canal was constructed by combining the rivers and streams along the coasts. In Thrissur District Kanoli canal starts from Kodungallur Taluk and passes through Kodungallur, Thrissur, Chavakkad and Mukundapuram Taluks. A complaint regarding encroachment of land in Kanoli Canal was received (May 2008) in the Chief Minister's Public Grievance Cell, Thiruvananthapuram. Chief Minister ordered time bound disposal of the case and stringent action against the encroachers. Deputy Director, Survey, Thrissur reported (January 2011) to the District Collector that there were 832 number of encroachments covering an area of 17.9673 hectares on the sides of Kanoli canal in four taluks in Thrissur District. District Collector, Thrissur (August 2011) informed Revenue Department that details of all encroachments with their sketches were passed on to Additional Irrigation Division, Thrissur for eviction. Executive Engineer, Additional Irrigation Division, Thrissur reported to the District Collector, Thrissur (April 2018) that since Kanoli Canal was declared as National Waterway 3 in 2016, eviction of encroachments would be undertaken by National Waterway Authority of India. But the fact remains that encroachments continued without eviction even after the lapse of nine years from the date of identification of encroachments. A joint site verification of Kanoli Canal (December 2019) at Chavakkad Taluk revealed large scale cultivation of coconut trees on both sides and across the canal obstructing and diverting the free flow of the river. Around six meters of the canal was filled with sand and fenced for private use. Local residents stated that the area adjacent to the canal was flooded in 2018 and they were shifted to relief camps.				
3.	**Bharathapuzha at Nambiar Pallam in Thrissur**	11	0.5136	Yes in March 2017
A complaint was received at District Collectorate, Thrissur regarding the encroachment of Bharathapuzha at Nambiar Pallam in March 2017. Tahsildar (Land Records), Thalappilly reported (June 2017) that encroachment was found in Bharathapuzha at Nambiar Pallam on preliminary enquiry but no natural boundary and survey stones were available to fix the river purambokku. After conducting the survey of the area in December 2018, Tahsildar, Thalappilly identified 11 number of encroachments covering an area of 0.5136 ha at Nambiar Pallam and requested the District Collector to release an amount of ₹28,000 incurred for planting survey stones at the site. Though funds were available in River Management Fund, the amount was not released till date. Encroachers were occupying the land for eight to 40 years. It was observed that though the complaint regarding river encroachment was received in March 2017, the survey to identify the extent of encroachment was carried out in December 2018 and no further action was taken till date.				

Sl. No.	Location details	Number of encroachments	Extent of land (in Ha)	Whether complaints received or not
4.	Uttarappalliyar river (Alappuzha)	47	NA**	Yes in 2007 and 2015
The original river course through Venmani, Ala, Cheriyanadu, Puliyoor and Ennakkad villages was blocked due to intermittent encroachments. As part of rejuvenation activities, survey and demarcation of boundaries of the river was attempted in April 2017. Though complaints were received in 2007 and 2015, action in this regard was initiated by the Revenue Department only on 17 April 2017 when Uttarappalliyar Rejuvenation Campaign was launched by pooling funds from River Management Fund for survey and demarcation of boundaries of the river. However, survey could not be conducted in three villages, as the resurvey records contained little or no trace of the river route in these villages. Unless a fresh survey is conducted using the Lithomaps and records prior to resurvey, and boundaries of the river demarcated, effective control of encroachment and rejuvenation of river path will not be realised. Though the Land Revenue Commissioner repeatedly sought detailed report from the District Collector on the scope of re-establishing the flow route of the river through the five villages, there was no response in file (December 2019). As the river used to serve as a balancing channel between the water levels in Achencovil river and Pamba river, its stagnancy caused severe floods in the villages during 2018.				
5.	Kuttamperoor river (Alappuzha)	NA**	NA**	Yes May 2008
The river flows through Ennakkad and Mannar Villages in Chengannur Taluk. The river has a length of 7.2 km in Alappuzha district. Continuous encroachment identified on either side of the river causing shrinkage of the width of the river to about 15m to 20m against the actual width of 70m. No survey of the entire stretch of the river was conducted till 2018 floods. The villages through which the river flowed were severely affected during 2018 flood. Irrigation Department took up (March 2019) rejuvenation of the river under NABARD assisted scheme, which is yet to be completed.				
6. District Collector Ernakulam stated that noticeable encroachments were not reported in the District. The justification is not tenable as survey of rivers is to be conducted in order to identify illegal encroachments in rivers. However, Audit observed that no survey of water bodies was conducted in Paravur, one of the selected Taluks. Detection of encroachments is not possible in the absence of survey and demarcation of boundaries of rivers.				

* Based on examination of files at respective field offices. ** Details not available

Appendix 2.2

Statement showing shortage of equipment, vehicles and infrastructural facilities in Kerala Fire and Rescue Services Academy

(Reference: Paragraph 2.6)

Sl. No.	Nature of shortage	Description	Number of items in possession	Number of items in shortage
1.	Equipment	Trailer Pump	5	Nil
2.		Portable Pump (serviceable)	1	Nil
3.		Generator (230 volt)	1	Nil
4.		BA Set (serviceable)	8	50
5.		SCUBA Set (serviceable)	3	20
6.		BA Compressor set (serviceable)	1	2
7.		Float pump	2	Nil
8.		Hydraulic equipment set (serviceable)	1	1
9.		Chain saw (serviceable)	2	10
10.		Concrete cutters (serviceable)	2	3
11.		Rubber Dinghy with OB engine	Nil	2
12.		Fibre Boat	Nil	2
13.		Fire Fighting Suit	Nil	70
14.		Chemical suits	Nil	25
15.		Pneumatic rescue tools	Nil	2 sets
16.		High pressure portable pumps	Nil	3
17.		Rope rescue kit and accessories	Nil	10 sets
18.		Life detectors	Nil	5
19.		Demolition hammers	Nil	3 sets
20.		Thermal imaging cameras	Nil	3
21.		Extinguishers	Nil	50
22.		Rope Launcher	Nil	2
23.		Leak arrest kit	Nil	5
24.		Canister	Nil	20
25.		Inflatable Tent	Nil	2
26.		Inflatable Light	1	3
27.		Portable Water Mist	Nil	5
28.		Exhaust Blower	Nil	2
29.		Basic life support accessories - Mannequins, AED etc. Choking arrester kits Stretchers etc.	 Nil 2	 3 sets each 10
30.		Multi-Purpose Rescue Tools	1	Nil
31.	Vehicles	Fire tender	1	Nil
32.		Mobilising bus (old - proposed for condemnation)	1	1
33.		Excavator	1	Nil
34.		Jeep	2	Nil
35.		Bolero Jeep	2	Nil
36.		Ambulance	Nil	2
37.		Water mist tender	Nil	1
38.		Emergency Rescue tender	1	1
39.		Quick response vehicle	1	1
40.		SCUBA Van	Nil	1
41.		Mess Van	Nil	1

Sl. No.	Nature of shortage	Description	Number of items in possession	Number of items in shortage
42.	Shortage of infrastructure facilities	Fire lab		
43.		Multipurpose rescue tower		
44.		Smart class rooms		
45.		Computer lab		
46.		BA smoke room gallery		
47.		Fire lift		
48.		Fixed firefighting installations models		
49.		Drill grounds - 8 acres additional		
50.		Conference room-under construction		
51.		Barrack-under proposal, design and approval stage		
52.		Library		
53.		Health club		

Appendix 3.1

Salient features of Mullaperiyar, Idukki, Idamalayar, Lower Periyar dams and Bhoothathankettu barrage

(Reference: Chapter 3, Paragraph on Reservoir operation)

Name of Dam/ Barrage and source of data	FRL[128] (m, MSL)	MWL[129] (m, MSL)	MDDL[130] (m, MSL)	Capacity at FRL (MCM)	Live[131] storage capacity (MCM)	Capacity at dead storage[132] level (MCM)	Free board[133] over MWL (m)	Spillway type and discharge design volume (cumecs)	Number, type and size of gates	Extent of catchment area (sq. km)	Discharge capacity (cumecs)
Mullaperiyar Dam (Irrigation Department)	-*	-*	41.45	-*	299.26	144.17	0.91	Vertical and radial shutter type, 3454.65	13 numbers 10.97 x 4.87 m (3 number of vertical gates) 12.19 x 4.87 m (10 number of radial gates)	602.95	59.46
Idukki dam Cheruthoni dam (KSEBL)	732.43	734.11	694.94	1996.34	1459.49	536.81	1.79	Chute, 5012	5 numbers of radial gates, 12.19 x 10.36 m	650.00	557.50
Idamalayar dam (KSEBL)	169.00	171.20	115.00	1089.80	1017.80	72.00	0.80	Ogee, 3248	4 number of radial gates, 11.5 x 9.7 m	380.79 (excluding 101 sq. km Nirar catchment)	NA
Lower Periyar dam (KSEBL)	253.00	256.00	237.74	5.30	4.50	0.80	1.00	Ogee, 11200	5 number of radial gates, 13.5 x 15.65 m	584.00	338.94
Bhoothathankettu barrage (Irrigation Department)	34.95			-				Electrically operated framed steel shutters with vertical lifting arrangements of chain pulley blocks equipped with counterweight boxes, 7079	3 numbers 9.14 x 10.36 m 12 numbers 12.19 x 9.14 m	3048.00	

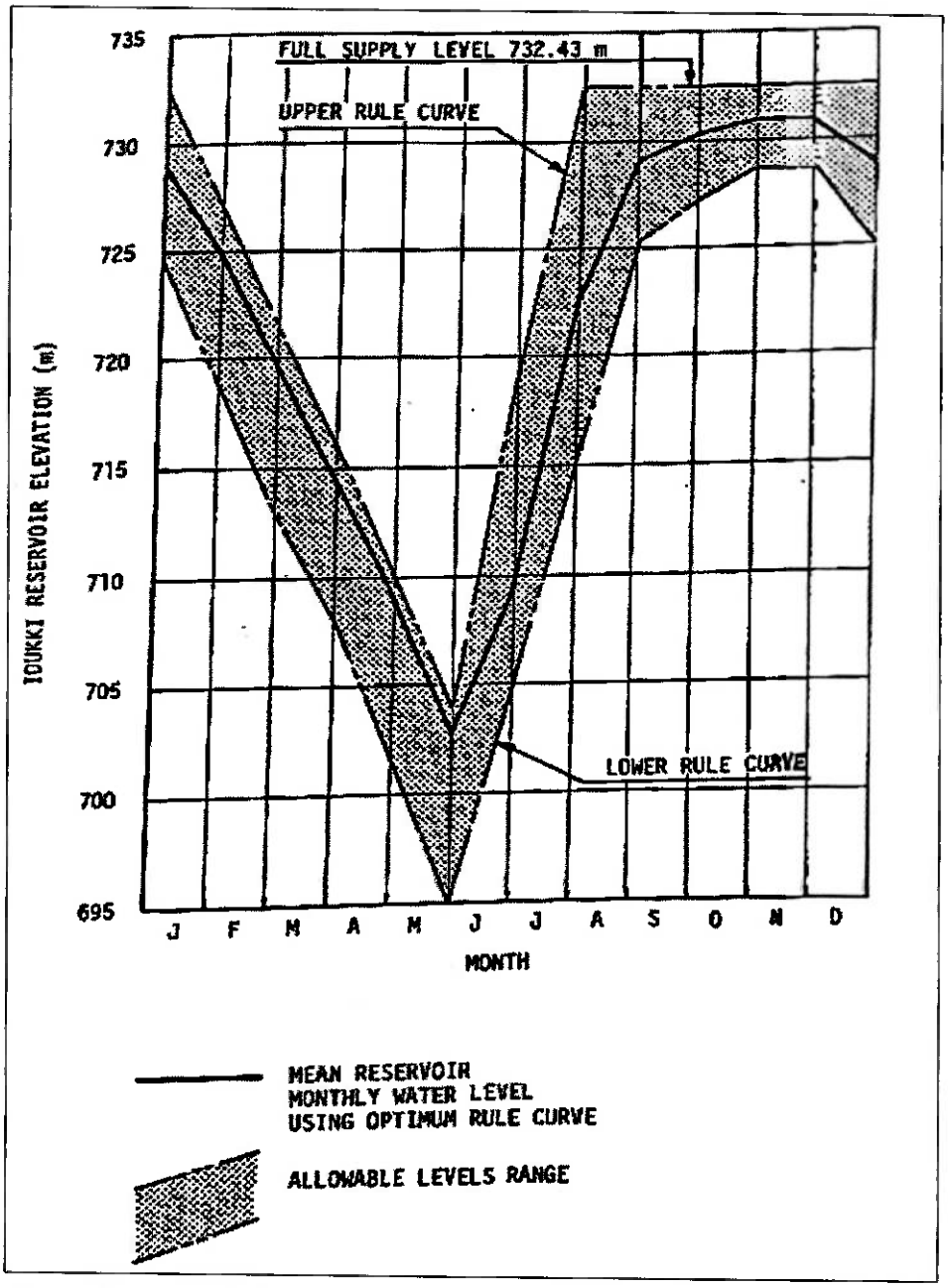
* matter is sub judice

[128] Full Reservoir Level (FRL) corresponds to the water level when the dam is filled to its full capacity
[129] Maximum Water Level (MWL) corresponds typically to the top level of the gates. At MWL, the flow over spillway will be at design flood discharge.
[130] Minimum Drawn Down Level
[131] Live storage is the storage between FRL and the dead storage level
[132] Dead storage is the minimum amount of water to be maintained in the dam
[133] The storage between MWL and FRL is available as flood cushion.

Appendix 3.2

Rule curve framed in 1983 for Idukki dam

(Reference: Paragraph 3.6.1)



(Source: Records at KSEBL)

Appendix 3.3

Rule curve framed in 2020 for Idukki and Idamalayar dams

(Reference: Paragraph 3.6.1)

Time Step	Reservoir Level in meter	
	Idukki	Idamalayar
June 10th	723.29	161.00
June 20th	723.29	161.00
June 30th	723.29	161.00
July 10th	724.00	161.50
July 20th	724.80	161.75
July 31st	725.60	162.50
August 10th	726.50	163.00
August 20th	727.50	163.50
August 31st	728.50	164.00
September 10th	729.25	165.00
September 20th	730.00	166.00
September 30th	730.59	166.30
October 10th	730.84	166.60
October 20th	731.17	166.80
October 31st	731.31	167.00
November 10th	731.46	168.50
November 20th	731.53	168.50
November 30th	731.53	168.50

Appendix 3.4

Procedure followed for conduct of simulations of reservoir operations using rule curves

(Reference: Paragraph 3.6.1)

The Idukki reservoir operation is analysed with the rule curves developed both in 1983 and 2020 whereas the Idamalayar reservoir operation is analysed with only the rule curve of 2020.
The reservoir operation was simulated by IISc, Bangalore for its study as follows

$$S_{t+1} = S_t + Q_t - R_t - E_t - Spill_t \quad \text{(Eq. A)}$$

where,

S_{t+1} reservoir storage at the end of the period t

S_t: reservoir storage at the beginning of the period t

Q_t: the inflow to the reservoir during the period t

R_t: release from the reservoir during the period t

E_t: evaporation loss from the water surface in the reservoir during the period t

$Spill_t$: excess water spilled from the reservoir during the period t

Period t is the time interval for which the reservoir operation is simulated. This may be for example a month, a day, an hour etc. All terms are expressed in volume units (MCM). Eq. A uses the principle of continuity. The rule curve analysis is carried out for the entire monsoon period from June to September 2018.

Appendix 3.5

Sample simulations of Idukki reservoir using 1983 rule curve

(Reference: Paragraph 3.6.2)

Day	Storage for upper levels (MCM)	Storage for lower rule levels (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6)	Spills (MCM)	Storage after spills (MCM)
	1a	1b	2	3	4	5	6	7	8	9
30-06-2018	1315.47	805.58	805.58	705.00	1.83	9.81	0.13	813.44	0.00	813.44
01-07-2018	1337.36	816.83	813.44	705.26	0.00	8.89	0.13	822.20	0.00	822.20
02-07-2018	1359.24	828.08	822.20	705.56	0.00	10.72	0.13	832.78	0.00	832.78
03-07-2018	1381.12	839.32	832.78	705.91	0.00	8.00	0.13	840.66	0.00	840.66
04-07-2018	1403.01	850.57	840.66	706.17	0.00	6.53	0.13	847.05	0.00	847.05
05-07-2018	1424.89	861.81	847.05	706.39	0.00	5.56	0.13	852.48	0.00	852.48
06-07-2018	1446.78	873.06	852.48	706.57	0.00	5.04	0.13	857.39	0.00	857.39
07-07-2018	1468.66	884.31	857.39	706.73	0.00	6.46	0.13	863.72	0.00	863.72
08-07-2018	1490.54	895.55	863.72	706.95	0.00	9.50	0.13	873.09	0.00	873.09
09-07-2018	1512.43	906.80	873.09	707.24	0.00	19.66	0.13	892.62	0.00	892.62
10-07-2018	1534.31	918.05	892.62	707.80	0.00	34.60	0.13	927.09	0.00	927.09
11-07-2018	1556.19	929.29	927.09	708.78	0.00	32.70	0.13	959.66	0.00	959.66
12-07-2018	1578.08	940.54	959.66	709.71	2.06	28.23	0.13	985.69	0.00	985.69
13-07-2018	1599.96	951.78	985.69	710.46	1.94	40.69	0.13	1024.31	0.00	1024.31
14-07-2018	1621.84	963.03	1024.31	711.56	1.85	33.21	0.13	1055.54	0.00	1055.54
15-07-2018	1643.73	974.28	1055.54	712.45	1.39	53.77	0.13	1107.78	0.00	1107.78
16-07-2018	1665.61	985.52	1107.78	713.85	1.59	61.92	0.13	1167.99	0.00	1167.99
17-07-2018	1687.49	996.77	1167.99	715.34	3.27	41.73	0.13	1206.32	0.00	1206.32
18-07-2018	1709.38	1008.02	1206.32	716.29	5.01	38.02	0.13	1239.20	0.00	1239.20
19-07-2018	1731.26	1019.26	1239.20	717.11	5.92	35.83	0.13	1268.98	0.00	1268.98
20-07-2018	1753.14	1030.51	1268.98	717.85	6.74	29.70	0.13	1291.81	0.00	1291.81
21-07-2018	1775.03	1041.75	1291.81	718.41	5.63	22.64	0.13	1308.69	0.00	1308.69
22-07-2018	1796.91	1053.00	1308.69	718.83	5.40	20.09	0.13	1323.25	0.00	1323.25
23-07-2018	1818.79	1064.25	1323.25	719.19	6.83	23.50	0.13	1339.79	0.00	1339.79
24-07-2018	1840.68	1075.49	1339.79	719.57	8.87	39.11	0.13	1369.90	0.00	1369.90

Day	Storage for upper levels (MCM)	Storage for lower rule levels (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6)	Spills (MCM)	Storage after spills (MCM)
	1a	1b	2	3	4	5	6	7	8	9
25-07-2018	1862.56	1086.74	1369.90	720.21	9.12	39.35	0.13	1399.99	0.00	1399.99
26-07-2018	1884.44	1097.99	1399.99	720.86	9.74	39.98	0.13	1430.10	0.00	1430.10
27-07-2018	1906.33	1109.23	1430.10	721.51	9.82	24.83	0.13	1444.99	0.00	1444.99
28-07-2018	1928.21	1120.48	1444.99	721.83	9.68	24.36	0.13	1459.54	0.00	1459.54
29-07-2018	1950.09	1131.72	1459.54	722.14	10.05	23.41	0.13	1472.78	0.00	1472.78
30-07-2018	1971.98	1142.97	1472.78	722.42	10.04	21.75	0.13	1484.36	0.00	1484.36
31-07-2018	1993.86	1154.22	1484.36	722.67	10.07	19.14	0.13	1493.29	0.00	1493.29
01-08-2018	1993.86	1168.36	1493.29	722.86	10.07	14.83	0.13	1497.92	0.00	1497.92
02-08-2018	1993.86	1182.51	1497.92	722.96	10.09	12.53	0.13	1500.23	0.00	1500.23
03-08-2018	1993.86	1196.66	1500.23	723.01	9.59	11.37	0.13	1501.89	0.00	1501.89
04-08-2018	1993.86	1210.81	1501.89	723.05	9.30	9.10	0.13	1501.55	0.00	1501.55
05-08-2018	1993.86	1224.96	1501.55	723.04	9.50	7.97	0.13	1499.89	0.00	1499.89
06-08-2018	1993.86	1239.11	1499.89	723.00	9.00	8.46	0.13	1499.23	0.00	1499.23
07-08-2018	1993.86	1253.26	1499.23	722.99	9.05	16.46	0.13	1506.50	0.00	1506.50
08-08-2018	1993.86	1267.40	1506.50	723.15	9.99	39.58	0.13	1535.96	0.00	1535.96
09-08-2018	1993.86	1281.55	1535.96	723.78	9.95	57.45	0.13	1583.33	0.00	1583.33
10-08-2018	1993.86	1295.70	1583.33	724.80	9.98	61.03	0.13	1634.26	0.00	1634.26
11-08-2018	1993.86	1309.85	1634.26	725.82	9.96	45.44	0.13	1669.62	0.00	1669.62
12-08-2018	1993.86	1324.00	1669.62	726.48	9.99	48.44	0.13	1707.94	0.00	1707.94
13-08-2018	1993.86	1338.15	1707.94	727.18	10.00	45.99	0.13	1743.80	0.00	1743.80
14-08-2018	1993.86	1352.30	1743.80	727.84	9.99	84.18	0.13	1817.86	0.00	1817.86
15-08-2018	1993.86	1366.44	1817.86	729.21	9.99	165.06	0.13	1972.80	0.00	1972.80
16-08-2018	1993.86	1380.59	1972.80	732.03	9.95	154.96	0.13	2117.68	123.82	1993.86
17-08-2018	1993.86	1394.74	1993.86	732.40	9.98	111.70	0.13	2095.45	101.59	1993.86
18-08-2018	1993.86	1408.89	1993.86	732.40	9.66	92.51	0.13	2076.58	82.72	1993.86
19-08-2018	1993.86	1423.04	1993.86	732.40	9.98	62.88	0.13	2046.63	52.77	1993.86
20-08-2018	1993.86	1437.19	1993.86	732.40	9.95	37.54	0.13	2021.33	27.46	1993.86
21-08-2018	1993.86	1451.34	1993.86	732.40	9.68	29.95	0.13	2014.00	20.14	1993.86
22-08-2018	1993.86	1465.48	1993.86	732.40	9.98	24.60	0.13	2008.35	14.49	1993.86
23-08-2018	1993.86	1479.63	1993.86	732.40	9.96	20.39	0.13	2004.16	10.30	1993.86

Day	Storage for upper levels (MCM)	Storage for lower rule levels (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6)	Spills (MCM)	Storage after spills (MCM)
	1a	1b	2	3	4	5	6	7	8	9
24-08-2018	1993.86	1493.78	1993.86	732.40	9.96	18.96	0.13	2002.72	8.86	1993.86
25-08-2018	1993.86	1507.93	1993.86	732.40	9.96	17.77	0.13	2001.55	7.68	1993.86
26-08-2018	1993.86	1522.08	1993.86	732.40	9.93	16.42	0.13	2000.22	6.35	1993.86
27-08-2018	1993.86	1536.23	1993.86	732.40	9.97	18.44	0.13	2002.20	8.34	1993.86
28-08-2018	1993.86	1550.38	1993.86	732.40	9.91	18.71	0.13	2002.53	8.67	1993.86
29-08-2018	1993.86	1564.52	1993.86	732.40	9.97	15.79	0.13	1999.55	5.69	1993.86
30-08-2018	1993.86	1578.67	1993.86	732.40	8.69	15.17	0.13	2000.21	6.35	1993.86
31-08-2018	1993.86	1592.82	1993.86	732.40	10.01	15.83	0.13	1999.56	5.69	1993.86
01-09-2018	1993.86	1596.33	1993.86	732.40	10.01	14.17	0.13	1997.89	4.03	1993.86
02-09-2018	1993.86	1599.84	1993.86	732.40	9.96	8.49	0.13	1992.26	0.00	1992.26
03-09-2018	1993.86	1603.35	1992.26	732.37	9.74	7.58	0.13	1989.98	0.00	1989.98
04-09-2018	1993.86	1606.86	1989.98	732.33	9.20	7.38	0.13	1988.03	0.00	1988.03
05-09-2018	1993.86	1610.36	1988.03	732.30	9.14	6.99	0.13	1985.74	0.00	1985.74
06-09-2018	1993.86	1613.87	1985.74	732.26	10.03	6.88	0.13	1982.47	0.00	1982.47
07-09-2018	1993.86	1617.38	1982.47	732.20	9.89	4.57	0.13	1977.01	0.00	1977.01
08-09-2018	1993.86	1620.89	1977.01	732.11	9.55	3.39	0.13	1970.72	0.00	1970.72
09-09-2018	1993.86	1624.40	1970.72	732.00	9.31	3.82	0.13	1965.09	0.00	1965.09
10-09-2018	1993.86	1627.91	1965.09	731.90	9.76	3.61	0.13	1958.81	0.00	1958.81
11-09-2018	1993.86	1631.42	1958.81	731.79	8.51	3.68	0.13	1953.85	0.00	1953.85
12-09-2018	1993.86	1634.93	1953.85	731.70	7.73	2.89	0.13	1948.89	0.00	1948.89
13-09-2018	1993.86	1638.43	1948.89	731.61	6.89	4.70	0.13	1946.57	0.00	1946.57
14-09-2018	1993.86	1641.94	1946.57	731.57	6.49	0.99	0.13	1940.94	0.00	1940.94
15-09-2018	1993.86	1645.45	1940.94	731.47	7.14	2.64	0.13	1936.31	0.00	1936.31
16-09-2018	1993.86	1648.96	1936.31	731.39	5.89	3.04	0.13	1933.33	0.00	1933.33
17-09-2018	1993.86	1652.47	1933.33	731.33	5.28	2.76	0.13	1930.68	0.00	1930.68
18-09-2018	1993.86	1655.98	1930.68	731.28	5.11	2.93	0.13	1928.37	0.00	1928.37
19-09-2018	1993.86	1659.49	1928.37	731.24	4.96	3.77	0.13	1927.04	0.00	1927.04
20-09-2018	1993.86	1662.99	1927.04	731.22	6.40	3.55	0.13	1924.06	0.00	1924.06
21-09-2018	1993.86	1666.50	1924.06	731.16	7.30	2.46	0.13	1919.10	0.00	1919.10
22-09-2018	1993.86	1670.01	1919.10	731.07	7.05	2.22	0.13	1914.13	0.00	1914.13

Day	Storage for upper levels (MCM)	Storage for lower rule levels (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6)	Spills (MCM)	Storage after spills (MCM)
	1a	1b	2	3	4	5	6	7	8	9
23-09-2018	1993.86	1673.52	1914.13	730.98	4.16	3.96	0.13	1913.80	0.00	1913.80
24-09-2018	1993.86	1677.03	1913.80	730.97	6.13	7.58	0.13	1915.12	0.00	1915.12
25-09-2018	1993.86	1680.54	1915.12	731.00	5.20	4.34	0.13	1914.13	0.00	1914.13
26-09-2018	1993.86	1684.05	1914.13	730.98	6.14	5.61	0.13	1913.47	0.00	1913.47
27-09-2018	1993.86	1687.56	1913.47	730.97	5.02	5.81	0.13	1914.13	0.00	1914.13
28-09-2018	1993.86	1691.06	1914.13	730.98	5.77	9.54	0.13	1917.77	0.00	1917.77
29-09-2018	1993.86	1694.57	1917.77	731.05	5.32	10.42	0.13	1922.74	0.00	1922.74

(Source: IISc, Bangalore's Report on Kerala Floods 2018)

Appendix 3.6

Sample simulations of Idukki reservoir using 2020 rule curve

(Reference: Paragraph 3.6.2)

Day	Storage for rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation Loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
10-06-2018	1513.98	1513.98	723.30	2.38	43.53	0.13	1555.00	41.02	1513.98
11-06-2018	1513.98	1513.98	723.30	3.52	52.36	0.13	1562.69	48.71	1513.98
12-06-2018	1513.98	1513.98	723.30	4.26	34.28	0.13	1543.87	29.89	1513.98
13-06-2018	1513.98	1513.98	723.30	2.18	25.39	0.13	1537.07	23.09	1513.98
14-06-2018	1513.98	1513.98	723.30	2.13	16.99	0.13	1528.71	14.73	1513.98
15-06-2018	1513.98	1513.98	723.30	1.33	12.95	0.13	1525.47	11.49	1513.98
16-06-2018	1513.98	1513.98	723.30	1.67	13.84	0.13	1526.02	12.04	1513.98
17-06-2018	1513.98	1513.98	723.30	2.10	7.62	0.13	1519.38	5.40	1513.98
18-06-2018	1513.98	1513.98	723.30	2.90	8.42	0.13	1519.38	5.39	1513.98
19-06-2018	1513.98	1513.98	723.30	1.63	9.86	0.13	1522.08	8.10	1513.98
20-06-2018	1513.98	1513.98	723.30	2.55	12.27	0.13	1523.57	9.58	1513.98
21-06-2018	1513.98	1513.98	723.30	2.27	13.21	0.13	1524.79	10.81	1513.98
22-06-2018	1513.98	1513.98	723.30	2.21	12.42	0.13	1524.06	10.08	1513.98
23-06-2018	1513.98	1513.98	723.30	3.88	12.61	0.13	1522.58	8.60	1513.98
24-06-2018	1513.98	1513.98	723.30	2.49	9.00	0.13	1520.37	6.39	1513.98
25-06-2018	1513.98	1513.98	723.30	2.43	10.90	0.13	1522.32	8.34	1513.98
26-06-2018	1513.98	1513.98	723.30	1.96	9.22	0.13	1521.10	7.12	1513.98
27-06-2018	1513.98	1513.98	723.30	1.40	10.37	0.13	1522.83	8.85	1513.98
28-06-2018	1513.98	1513.98	723.30	1.62	10.35	0.13	1522.58	8.60	1513.98
29-06-2018	1513.98	1513.98	723.30	1.37	8.87	0.13	1521.35	7.37	1513.98
30-06-2018	1513.98	1513.98	723.30	1.83	9.81	0.13	1521.83	4.59	1517.24
01-07-2018	1517.24	1517.24	723.37	1.40	8.89	0.13	1524.60	4.10	1520.50

Day	Storage for rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation Loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
02-07-2018	1520.50	1520.50	723.44	2.49	10.72	0.13	1528.60	4.84	1523.76
03-07-2018	1523.76	1523.76	723.51	2.23	8.00	0.13	1529.41	2.38	1527.03
04-07-2018	1527.03	1527.03	723.58	2.72	6.53	0.13	1530.70	0.41	1530.29
05-07-2018	1530.29	1530.29	723.65	2.99	5.56	0.13	1532.73	0.00	1532.73
06-07-2018	1533.55	1532.73	723.70	2.71	5.04	0.13	1534.92	0.00	1534.92
07-07-2018	1536.81	1534.92	723.75	2.66	6.46	0.13	1538.59	0.00	1538.59
08-07-2018	1540.07	1538.59	723.83	1.03	9.50	0.13	1546.93	3.59	1543.33
09-07-2018	1543.33	1543.33	723.93	1.85	19.66	0.13	1561.02	14.42	1546.59
10-07-2018	1546.59	1546.59	724.00	3.05	34.60	0.13	1578.01	27.60	1550.41
11-07-2018	1550.41	1550.41	724.08	1.16	32.70	0.13	1581.82	27.59	1554.23
12-07-2018	1554.23	1554.23	724.17	2.06	28.23	0.13	1580.26	22.22	1558.05
13-07-2018	1558.05	1558.05	724.25	1.94	40.69	0.13	1596.66	34.80	1561.86
14-07-2018	1561.86	1561.86	724.33	1.85	33.21	0.13	1593.10	27.42	1565.68
15-07-2018	1565.68	1565.68	724.42	1.39	53.77	0.13	1617.92	48.42	1569.50
16-07-2018	1569.50	1569.50	724.50	1.59	61.92	0.13	1629.70	56.39	1573.32
17-07-2018	1573.32	1573.32	724.57	3.27	41.73	0.13	1611.65	34.52	1577.13
18-07-2018	1577.13	1577.13	724.65	5.01	38.02	0.13	1610.01	29.06	1580.95
19-07-2018	1580.95	1580.95	724.72	5.92	35.83	0.13	1610.73	25.96	1584.77
20-07-2018	1584.77	1584.77	724.80	6.74	29.70	0.13	1607.60	19.13	1588.47
21-07-2018	1588.47	1588.47	724.87	5.63	22.64	0.13	1605.35	13.18	1592.16
22-07-2018	1592.16	1592.16	724.95	5.40	20.09	0.13	1606.72	10.86	1595.86
23-07-2018	1595.86	1595.86	725.02	6.83	23.50	0.13	1612.40	12.84	1599.56
24-07-2018	1599.56	1599.56	725.09	8.87	39.11	0.13	1629.67	26.41	1603.26
25-07-2018	1603.26	1603.26	725.16	9.12	39.35	0.13	1633.36	26.40	1606.96
26-07-2018	1606.96	1606.96	725.24	9.74	39.98	0.13	1637.07	26.41	1610.66
27-07-2018	1610.66	1610.66	725.31	9.82	24.83	0.13	1625.54	11.19	1614.35
28-07-2018	1614.35	1614.35	725.38	9.68	24.36	0.13	1628.91	10.85	1618.05
29-07-2018	1618.05	1618.05	725.45	10.05	23.41	0.13	1631.29	9.54	1621.75

Day	Storage for rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation Loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
30-07-2018	1621.75	1621.75	725.53	10.04	21.75	0.13	1633.33	7.88	1625.45
31-07-2018	1625.45	1625.45	725.60	10.07	19.14	0.13	1634.38	4.30	1630.08
01-08-2018	1630.08	1630.08	725.69	10.07	14.83	0.13	1634.71	0.00	1634.71
02-08-2018	1634.71	1634.71	725.78	10.09	12.53	0.13	1637.02	0.00	1637.02
03-08-2018	1639.34	1637.02	725.83	9.59	11.37	0.13	1638.67	0.00	1638.67
04-08-2018	1643.97	1638.67	725.86	9.30	9.10	0.13	1638.34	0.00	1638.34
05-08-2018	1648.60	1638.34	725.85	9.50	7.97	0.13	1636.68	0.00	1636.68
06-08-2018	1653.23	1636.68	725.82	9.00	8.46	0.13	1636.01	0.00	1636.01
07-08-2018	1657.86	1636.01	725.81	9.05	16.46	0.13	1643.29	0.00	1643.29
08-08-2018	1662.49	1643.29	725.95	9.99	39.58	0.13	1672.75	5.63	1667.12
09-08-2018	1667.12	1667.12	726.41	9.95	57.45	0.13	1714.49	42.74	1671.75
10-08-2018	1671.75	1671.75	726.50	9.98	61.03	0.13	1722.68	45.50	1677.18
11-08-2018	1677.18	1677.18	726.60	9.96	45.44	0.13	1712.54	29.92	1682.61
12-08-2018	1682.61	1682.61	726.70	9.99	48.44	0.13	1720.93	32.89	1688.04
13-08-2018	1688.04	1688.04	726.80	10.00	45.99	0.13	1723.90	30.43	1693.47
14-08-2018	1693.47	1693.47	726.90	9.99	84.18	0.13	1767.54	68.63	1698.91
15-08-2018	1698.91	1698.91	727.00	9.99	165.06	0.13	1853.85	149.51	1704.34
16-08-2018	1704.34	1704.34	727.10	9.95	154.96	0.13	1849.22	139.45	1709.77
17-08-2018	1709.77	1709.77	727.20	9.98	111.70	0.13	1811.36	96.16	1715.20
18-08-2018	1715.20	1715.20	727.30	9.66	92.51	0.13	1797.92	77.29	1720.63
19-08-2018	1720.63	1720.63	727.40	9.98	62.88	0.13	1773.40	47.34	1726.06
20-08-2018	1726.06	1726.06	727.50	9.95	37.54	0.13	1753.53	22.51	1731.01
21-08-2018	1731.01	1731.01	727.59	9.68	29.95	0.13	1751.16	15.19	1735.96
22-08-2018	1735.96	1735.96	727.68	9.98	24.60	0.13	1750.45	9.53	1740.91
23-08-2018	1740.91	1740.91	727.77	9.96	20.39	0.13	1751.21	5.35	1745.86
24-08-2018	1745.86	1745.86	727.86	9.96	18.96	0.13	1754.73	3.91	1750.81
25-08-2018	1750.81	1750.81	727.95	9.96	17.77	0.13	1758.50	2.73	1755.76
26-08-2018	1755.76	1755.76	728.05	9.93	16.42	0.13	1762.12	1.40	1760.71
27-08-2018	1760.71	1760.71	728.14	9.97	18.44	0.13	1769.05	3.39	1765.66

Day	Storage for rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation Loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
28-08-2018	1765.66	1765.66	728.23	9.91	18.71	0.13	1774.33	3.72	1770.62
29-08-2018	1770.62	1770.62	728.32	9.97	15.79	0.13	1776.31	0.74	1775.57
30-08-2018	1775.57	1775.57	728.41	8.69	15.17	0.13	1781.92	1.40	1780.52
31-08-2018	1780.52	1780.52	728.50	10.01	15.83	0.13	1786.21	1.66	1784.55
01-09-2018	1784.55	1784.55	728.57	10.01	14.17	0.13	1788.58	0.00	1788.58
02-09-2018	1788.58	1788.58	728.65	9.96	8.49	0.13	1786.98	0.00	1786.98
03-09-2018	1792.61	1786.98	728.62	9.74	7.58	0.13	1784.70	0.00	1784.70
04-09-2018	1796.65	1784.70	728.58	9.20	7.38	0.13	1782.74	0.00	1782.74
05-09-2018	1800.68	1782.74	728.54	9.14	6.99	0.13	1780.46	0.00	1780.46
06-09-2018	1804.71	1780.46	728.50	10.03	6.88	0.13	1777.18	0.00	1777.18
07-09-2018	1808.74	1777.18	728.44	9.89	4.57	0.13	1771.73	0.00	1771.73
08-09-2018	1812.78	1771.73	728.34	9.55	3.39	0.13	1765.44	0.00	1765.44
09-09-2018	1816.81	1765.44	728.22	9.31	3.82	0.13	1759.81	0.00	1759.81
10-09-2018	1820.84	1759.81	728.12	9.76	3.61	0.13	1753.53	0.00	1753.53
11-09-2018	1824.88	1753.53	728.00	8.51	3.68	0.13	1748.57	0.00	1748.57
12-09-2018	1828.92	1748.57	727.91	7.73	2.89	0.13	1743.61	0.00	1743.61
13-09-2018	1832.95	1743.61	727.82	6.89	4.70	0.13	1741.29	0.00	1741.29
14-09-2018	1836.99	1741.29	727.78	6.49	0.99	0.13	1735.66	0.00	1735.66
15-09-2018	1841.03	1735.66	727.68	7.14	2.64	0.13	1731.03	0.00	1731.03
16-09-2018	1845.07	1731.03	727.59	5.89	3.04	0.13	1728.05	0.00	1728.05
17-09-2018	1849.10	1728.05	727.54	5.28	2.76	0.13	1725.40	0.00	1725.40
18-09-2018	1853.14	1725.40	727.49	5.11	2.93	0.13	1723.08	0.00	1723.08
19-09-2018	1857.18	1723.08	727.45	4.96	3.77	0.13	1721.76	0.00	1721.76
20-09-2018	1861.22	1721.76	727.42	6.40	3.55	0.13	1718.78	0.00	1718.78
21-09-2018	1864.41	1718.78	727.37	7.30	2.46	0.13	1713.82	0.00	1713.82
22-09-2018	1867.60	1713.82	727.28	7.05	2.22	0.13	1708.85	0.00	1708.85
23-09-2018	1870.80	1708.85	727.18	4.16	3.96	0.13	1708.52	0.00	1708.52
24-09-2018	1873.99	1708.52	727.18	6.13	7.58	0.13	1709.84	0.00	1709.84
25-09-2018	1877.19	1709.84	727.20	5.20	4.34	0.13	1708.85	0.00	1708.85

Day	Storage for rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation Loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
26-09-2018	1880.38	1708.85	727.18	6.14	5.61	0.13	1708.19	0.00	1708.19
27-09-2018	1883.57	1708.19	727.17	5.02	5.81	0.13	1708.85	0.00	1708.85
28-09-2018	1886.77	1708.85	727.18	5.77	9.54	0.13	1712.49	0.00	1712.49
29-09-2018	1889.96	1712.49	727.25	5.32	10.42	0.13	1717.46	0.00	1717.46

(Source: IISc, Bangalore's Report on Kerala Floods 2018)

Appendix 3.7

Sample simulations of Idamalayar reservoir using 2020 rule curve

(Reference: Paragraph 3.6.3)

Day	Storage for the rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
10-06-2018	860.00	860.00	161.00	1.77	28.30	0.00	886.53	26.53	860.00
11-06-2018	860.00	860.00	161.00	1.12	23.16	0.00	882.04	22.04	860.00
12-06-2018	860.00	860.00	161.00	1.38	26.34	0.00	884.96	24.96	860.00
13-06-2018	860.00	860.00	161.00	1.30	22.60	0.00	881.30	21.30	860.00
14-06-2018	860.00	860.00	161.00	2.16	24.18	0.05	881.96	21.96	860.00
15-06-2018	860.00	860.00	161.00	0.32	16.33	0.04	875.98	15.98	860.00
16-06-2018	860.00	860.00	161.00	0.56	10.58	0.02	869.99	9.99	860.00
17-06-2018	860.00	860.00	161.00	1.15	11.14	0.00	869.99	9.99	860.00
18-06-2018	860.00	860.00	161.00	0.81	8.28	0.02	867.46	7.46	860.00
19-06-2018	860.00	860.00	161.00	1.95	8.46	0.05	866.46	6.46	860.00
20-06-2018	860.00	860.00	161.00	0.76	10.68	0.04	869.88	9.88	860.00
21-06-2018	860.00	860.00	161.00	0.59	13.29	0.00	872.70	12.70	860.00
22-06-2018	860.00	860.00	161.00	0.61	13.66	0.02	873.04	13.04	860.00
23-06-2018	860.00	860.00	161.00	0.53	12.93	0.02	872.38	12.38	860.00
24-06-2018	860.00	860.00	161.00	0.54	7.53	0.03	866.97	6.97	860.00
25-06-2018	860.00	860.00	161.00	0.62	7.62	0.03	866.97	6.97	860.00
26-06-2018	860.00	860.00	161.00	0.34	8.85	0.00	868.51	8.51	860.00
27-06-2018	860.00	860.00	161.00	0.68	7.30	0.03	866.58	6.58	860.00
28-06-2018	860.00	860.00	161.00	1.49	10.02	0.01	868.51	8.51	860.00
29-06-2018	860.00	860.00	161.00	0.54	10.21	0.00	869.67	9.67	860.00
30-06-2018	860.00	860.00	161.00	0.44	9.86	0.03	869.38	7.97	861.41
01-07-2018	861.41	861.41	161.05	0.36	7.63	0.02	868.66	5.83	862.83
02-07-2018	862.83	862.83	161.10	0.28	7.25	0.04	869.76	5.51	864.25

Day	Storage for the rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
03-07-2018	864.25	864.25	161.15	0.73	7.87	0.00	871.39	5.73	865.66
04-07-2018	865.66	865.66	161.20	0.75	5.83	0.04	870.70	3.62	867.08
05-07-2018	867.08	867.08	161.25	0.61	4.03	0.06	870.44	1.95	868.49
06-07-2018	868.49	868.49	161.30	1.20	3.74	0.02	871.01	1.10	869.90
07-07-2018	869.90	869.90	161.35	1.63	4.21	0.06	872.42	1.10	871.32
08-07-2018	871.32	871.32	161.40	1.26	6.72	0.00	876.78	4.05	872.73
09-07-2018	872.73	872.73	161.45	0.29	9.49	0.00	881.93	7.78	874.15
10-07-2018	874.15	874.15	161.50	0.29	17.45	0.00	891.31	16.45	874.86
11-07-2018	874.86	874.86	161.53	0.45	39.76	0.00	914.18	38.61	875.56
12-07-2018	875.56	875.56	161.55	0.35	29.87	0.00	905.08	28.81	876.27
13-07-2018	876.27	876.27	161.58	0.56	21.40	0.00	897.12	20.14	876.98
14-07-2018	876.98	876.98	161.60	0.53	28.63	0.02	905.06	27.38	877.69
15-07-2018	877.69	877.69	161.63	0.34	27.81	0.00	905.16	26.77	878.39
16-07-2018	878.39	878.39	161.65	0.42	40.34	0.00	918.31	39.21	879.10
17-07-2018	879.10	879.10	161.68	0.18	37.63	0.00	916.55	36.74	879.81
18-07-2018	879.81	879.81	161.70	0.61	32.01	0.00	911.21	30.69	880.52
19-07-2018	880.52	880.52	161.73	0.49	28.81	0.06	908.78	27.55	881.23
20-07-2018	881.23	881.23	161.75	0.82	24.34	0.00	904.75	21.58	883.17
21-07-2018	883.17	883.17	161.82	1.64	24.18	0.03	905.68	20.56	885.11
22-07-2018	885.11	885.11	161.89	0.98	19.46	0.08	903.51	16.45	887.05
23-07-2018	887.05	887.05	161.95	2.30	15.41	0.00	900.16	11.17	889.00
24-07-2018	889.00	889.00	162.02	4.02	23.14	0.00	908.12	17.18	890.94
25-07-2018	890.94	890.94	162.09	4.90	39.95	0.00	925.99	33.11	892.88
26-07-2018	892.88	892.88	162.16	5.93	21.48	0.00	908.44	13.61	894.83
27-07-2018	894.83	894.83	162.23	5.76	19.60	0.02	908.65	11.88	896.77
28-07-2018	896.77	896.77	162.30	5.19	12.42	0.03	903.97	5.26	898.71
29-07-2018	898.71	898.71	162.36	5.84	16.78	0.00	909.66	9.00	900.66

Day	Storage for the rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
30-07-2018	900.66	900.66	162.43	5.73	13.83	0.03	908.72	6.12	902.60
31-07-2018	902.60	902.60	162.50	5.84	19.96	0.00	916.72	12.69	904.03
01-08-2018	904.03	904.03	162.55	5.81	10.74	0.02	908.94	3.48	905.46
02-08-2018	905.46	905.46	162.60	5.82	9.03	0.03	908.64	1.75	906.89
03-08-2018	906.89	906.89	162.65	5.81	9.62	0.05	910.65	2.33	908.32
04-08-2018	908.32	908.32	162.70	5.77	7.61	0.11	910.05	0.30	909.75
05-08-2018	909.75	909.75	162.75	5.77	6.72	0.08	910.62	0.00	910.62
06-08-2018	911.18	910.62	162.78	5.78	7.83	0.03	912.64	0.03	912.61
07-08-2018	912.61	912.61	162.85	5.77	19.07	0.00	925.91	11.87	914.04
08-08-2018	914.04	914.04	162.90	5.71	61.93	0.00	970.27	54.80	915.47
09-08-2018	915.47	915.47	162.95	5.67	46.37	0.00	956.18	39.28	916.90
10-08-2018	916.90	916.90	163.00	5.67	33.92	0.00	945.15	26.82	918.33
11-08-2018	918.33	918.33	163.05	5.69	17.28	0.00	929.92	10.16	919.76
12-08-2018	919.76	919.76	163.10	5.69	31.81	0.07	945.80	24.61	921.19
13-08-2018	921.19	921.19	163.15	5.47	37.08	0.00	952.80	30.18	922.62
14-08-2018	922.62	922.62	163.20	5.40	62.96	0.00	980.18	56.13	924.05
15-08-2018	924.05	924.05	163.25	1.96	100.59	0.00	1022.68	97.20	925.48
16-08-2018	925.48	925.48	163.30	0.00	86.97	0.00	1012.45	85.54	926.91
17-08-2018	926.91	926.91	163.35	0.00	52.67	0.00	979.58	51.24	928.34
18-08-2018	928.34	928.34	163.40	0.00	34.81	0.00	963.15	33.38	929.77
19-08-2018	929.77	929.77	163.45	0.01	28.17	0.00	957.92	26.72	931.20
20-08-2018	931.20	931.20	163.50	3.91	21.94	0.00	949.23	16.73	932.50
21-08-2018	932.50	932.50	163.55	4.48	15.16	0.00	943.17	9.37	933.80
22-08-2018	933.80	933.80	163.59	5.82	12.41	0.03	940.36	5.26	935.10
23-08-2018	935.10	935.10	163.64	5.26	10.39	0.00	940.23	3.83	936.40
24-08-2018	936.40	936.40	163.68	4.93	8.57	0.04	940.01	2.31	937.70
25-08-2018	937.70	937.70	163.73	5.70	6.89	0.06	938.83	0.00	938.83

Day	Storage for the rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
26-08-2018	939.00	938.83	163.77	5.77	7.14	0.04	940.17	0.00	940.17
27-08-2018	940.30	940.17	163.81	5.77	7.57	0.06	941.90	0.30	941.60
28-08-2018	941.60	941.60	163.86	5.72	7.43	0.02	943.29	0.39	942.90
29-08-2018	942.90	942.90	163.91	5.84	7.11	0.05	944.12	0.00	944.12
30-08-2018	944.20	944.12	163.95	5.85	5.80	0.03	944.05	0.00	944.05
31-08-2018	945.50	944.05	163.95	5.84	6.71	0.02	944.90	0.00	944.90
01-09-2018	948.38	944.90	163.98	5.85	6.71	0.01	945.75	0.00	945.75
02-09-2018	951.26	945.75	164.01	5.84	6.42	0.06	946.27	0.00	946.27
03-09-2018	954.14	946.27	164.03	5.84	6.42	0.05	946.79	0.00	946.79
04-09-2018	957.02	946.79	164.04	5.87	5.87	0.08	946.71	0.00	946.71
05-09-2018	959.90	946.71	164.04	5.88	5.88	0.05	946.66	0.00	946.66
06-09-2018	962.78	946.66	164.04	5.92	5.64	0.14	946.24	0.00	946.24
07-09-2018	965.66	946.24	164.03	5.99	5.71	0.10	945.87	0.00	945.87
08-09-2018	968.54	945.87	164.01	6.01	5.76	0.06	945.55	0.00	945.55
09-09-2018	971.42	945.55	164.00	6.01	6.19	0.09	945.64	0.00	945.64
10-09-2018	974.30	945.64	164.00	5.99	4.54	0.11	944.08	0.00	944.08
11-09-2018	977.18	944.08	163.95	6.00	0.00	0.11	937.98	0.00	937.98
12-09-2018	980.06	937.98	163.74	6.00	1.53	0.09	933.42	0.00	933.42
13-09-2018	982.94	933.42	163.58	6.00	0.98	0.11	928.29	0.00	928.29
14-09-2018	985.82	928.29	163.40	5.36	0.93	0.14	923.73	0.00	923.73
15-09-2018	988.70	923.73	163.24	5.94	1.14	0.05	918.88	0.00	918.88
16-09-2018	991.58	918.88	163.07	5.55	0.79	0.09	914.04	0.00	914.04
17-09-2018	994.46	914.04	162.90	5.46	0.95	0.05	909.48	0.00	909.48
18-09-2018	997.34	909.48	162.74	5.75	1.84	0.05	905.51	0.00	905.51
19-09-2018	1000.22	905.51	162.60	5.45	0.00	0.04	900.03	0.00	900.03
20-09-2018	1003.10	900.03	162.41	4.53	1.43	0.02	896.91	0.00	896.91
21-09-2018	1003.96	896.91	162.30	5.43	0.10	0.05	891.54	0.00	891.54

Day	Storage for the rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
22-09-2018	1004.83	891.54	162.11	5.65	0.63	0.07	886.44	0.00	886.44
23-09-2018	1005.69	886.44	161.93	5.89	1.18	0.10	881.63	0.00	881.63
24-09-2018	1006.56	881.63	161.76	4.67	2.81	0.10	879.67	0.00	879.67
25-09-2018	1007.42	879.67	161.69	5.89	3.09	0.00	876.87	0.00	876.87
26-09-2018	1008.28	876.87	161.60	5.38	0.65	0.03	872.11	0.00	872.11
27-09-2018	1009.15	872.11	161.43	5.94	1.26	0.08	867.35	0.00	867.35
28-09-2018	1010.01	867.35	161.26	5.70	0.73	0.07	862.31	0.00	862.31
29-09-2018	1010.88	862.31	161.08	5.68	2.42	0.10	858.95	0.00	858.95

(Source: IISc, Bangalore's Report on Kerala Floods 2018)