सत्यमेव जयते
NITI Aayog

Report of the Committee Constituted for Formulation of Strategy for Flood Management Works in Entire Country and River Management Activities and Works Related to Border Areas (2021– 26)

January, 2021

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Publisher

NATIONAL INSTITUTION FOR TRANSFORMING INDIA, NEW DELHI

Date of Publication: **January 2021**

Year of Publishing: **2021**

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Preface

Water is one of the greatest assets under the possession of mankind. It is a source of life but when challenged, it also has ability to destroy the whole life structures. Throughout the history of mankind, floods have brought untold wealth and prosperity to civilizations. Some of our most prosperous civilizations flourished on the flood plains and the fertile great northern plain of India which produces nearly 60 percent of our food grains is result of sediments brought by the floods of Indus-Ganga-Brahmaputra and their tributaries. Yet at the same time, floods have caused tremendous losses and resulted in untold suffering for millions of people. Even today, floods lead all natural disasters in the number of people affected and in resultant economic losses, with these numbers rising at alarming rates.

In response to such disaster, we have to move from the current paradigm of post-disaster response. Plans and efforts must be undertaken to break the current event-disaster cycle. More than ever, there is the need for decision makers to adopt holistic approaches for flood disaster management. In this current report, NITI Aayog has tried to focus on the main causes of the floods which in turn give us the sustainable solutions for this disaster. The report has clearly endorsed that the effective and long lasting strategy involves combination of - structural and non-structural measures along with the use of modern technology which can alleviate the problem of floods to a great degree.

Our last experiences have clearly demonstrated that we need a paradigm shift from our conventional approach of dam building to more non-structural measures like flood plain zoning, flood forecasting, reservoir operations and state of art space technology. Along with this, we have to focus on building a National Water Model for India which with the help of some scalable models can be used to feed the information into a decision support system which can provide support services to Nation by predicting and forecasting flood and other water related events. This technology and their predictions will further assist us in making flawless Flood Management plans.

One thing which every decision maker has to understand is that floods are not something which we have to prevent. It is the destruction of livelihood which has to be minimized by leaving the room of the river. Like any other natural entity, rivers have their own course and methods of operation and in order to minimize the loss and destruction we have to develop a sustainable ecology wherein both mankind and nature can benefit from each other.

(Rajiv Kumar)

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प्रो. रमेश चन्द
सदस्य
Prof. Ramesh Chand
MEMBER

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Message

Flood is the most prevalent and costliest natural disaster in the world which devastates both life and economy on large extent. Extreme flooding events are not relegated to the least developed nations, but can also devastate and ravage the most economically advanced and industrialized nations. The effective and long lasting strategy not only involves structural and non-structural measures but also some important measures like river rejuvenation, watershed development, land use planning, tree horticulture along the banks of the rivers, creation of lakes and wet lands in both rural and urban areas for flood management and water security. Through this report, NITI Aayog has tried to explore all these options and present a comprehensive strategy for flood management in entire country.

(Ramesh Chand)
30.12.2020

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अमिताभ कांत
Amitabh Kant
मुख्य कार्यकारी अधिकारी
Chief Executive Officer

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Foreword

The Kerala flood of 2018 was less intense than that of 1924 one, the biggest in Kerala's history till then. Yet it caused the unprecedented loss of lives, property and infrastructure. The mighty rivers ruptured their banks and floodwaters gushed through the structures constructed on the floodplains. Major reasons for the flood of such magnitude are unplanned construction and encroachment on riverbeds that have reduced the capacity of rivers to carry flood waters. Unfortunately, this is not just the picture from one disaster but in India the soaring rise in the damage from the flood is result of the heedless construction and increasing activities in flood plains.

Flood plain zoning which is neglected in almost every effort of flood control and management has to be one of the most important focal point of our strategy to manage floods. The lack of protection of river floodplains from reprehensible acts like encroachment affects both the river as well as those who encroach it adversely. Therefore NITI Aayog through "Report of the Committee constituted for formulation of strategy for Flood Management Works in entire country and River Management Activities and works related to Border Areas (2020 – 23)" has focused on encouraging the States to adopt flood plain zoning.

Technology can also play an important role in tackling floods and it is very heartening to see that we as a Nation have deciphered the way to it. The Central Water Commission is collaborating with M/s Google Inc., to provide inundation alerts based on the Flood Forecast available in Common Alerting Protocol (CAP) platform using high quality Digital Terrain Models available with Google using Artificial Intelligence and Machine Learning. The system started functioning from 2018 when inundation alerts were provided for Patna Gandhighat forecast stations. In similar manner, Odisha is the first State in the country that has implemented an Early Warning Dissemination System (EWDS) which aims at establishing a foolproof communication system to address the existing gap of disseminating disaster warning from the State, District and Block levels to communities. The Government of Kerala has also entrusted the Kerala State IT Mission (KSITM) to set up an ICT Platform comprising of Web based backend and a mobile app-based field survey application to document the flood related damage caused to houses and commercial establishments in affected districts. Recently, students from IIT Madras have developed an AI-enabled drone that can help authorities provide vital information on people trapped in disaster-hit areas. All these examples show that innovations in flood forecasting and management can lead the way for timely evictions and minimize the losses from the flood.

The report covers the constitutional position of the flood, approach and methodology for mitigation of flood which focuses on non-structural and structural measures, efficacy of past flood management programmes and way forward in terms of early warning system, flood inundation level and decision support system.

The present report is the result of incessant efforts of many people. I would like to acknowledge the efforts of all the committee members which have come together under the able and excellent leadership of Dr. Rajiv Kumar, Vice Chairman, NITI Aayog to produce this report. My special thanks to Member, NITI Aayog, Dr. Ramesh Chand and Secretary, Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti, Shri U.P Singh for the continuous support and guidance in making of Report.

I would also acknowledge the efforts of Adviser (Water Resources) and Member Secretary of the Committee, Shri Avinash Mishra and his team for convening the meetings, collating the inputs and report writing.

With each disaster, there are numerous lessons to be learnt. India needs to observe, document and ensure that these lessons are captured in the form of knowledge, which coupled with modern technology can help the states in handling the disasters of the future.

(Amitabh Kant)

Dated- December, 2020
Place- New Delhi

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List of Abbreviations

AI	Artificial Intelligence
ALTM	Airborne Laser Terrain Mapping
ANN	Artificial Neural Network
ARG	Automatic Rain Gauge
AWS	Automatic Weather Station
BB	Brahmaputra Board
BCM	Billion Cubic Meter
BEB	Beach Erosion Board
CAG	Comptroller and Auditor General
CAP	Common Alerting Patrol
C-DoT	Centre for Development of Telematics
CMIS	Coastal Management Information System
CMP	Crises Management Plan
CONUS	Continental United States
CPDAC	Coastal Protection and Development Advisory Committee
CWC	Central Water Commission
DM	Dam Management
DMSP	Disaster Management Support Programme
DoWR, RD, GR	Department of Water Resources, River Development & Ganga Rejuvenation
DPR	Detailed Project Report
DRIP	Dam Rehabilitation and Improvement Project
DTM	Digital Terrain Model
DoLR	Department of Land Resources
DSS	Decision Support System
DVC	Damodar Valley Corporation
EoCs	Emergency Operations Centers
EAP	Emergency Action Plan
FCI	Flood Control Infrastructure

FCMT	Flood Crises Management Team
FF	Flood Forecast
FMBAP	Flood Management and Border Area Programme
FMP	Flood Management Programme
FMPs	Flood Management Plans
FRL	Full Reservoir Level
FYP	Five Year Plan
GA	Genetic Algorithms
GFCC	Ganga Flood Control Commission
GHLSC	Gandak High Level Standing Committee
GIS	Geographic Information System
IISc	Indian Institute of Science
IIT	Indian Institute of Technology
IMC	Inter- Ministerial Committee
IMD	India Meteorological Department
IoT	Internet of Things
IRO	Integrated Reservoir Operation
KHLC	Kosi High Level Committee
MEA	Ministry of External Affairs
Mha	Million Hectare
MHA	Ministry of Home Affairs
ML	Machine Learning
MoCIT	Ministry of Communication and Information Technology
MoEFCC	Ministry of Environment, Forest and Climate Change
NDMA	National Disaster Management Authority
NGO	Non-Governmental Organization
NHP	National Hydrology Project
NIT	National Institute of Technology
NDRF	National Disaster Relief Fund
NRSC	National Remote Sensing Centre
NWDA	National Water Development Authority
NWIC	National Water Information Center

NWM	National Water Mission
NWM	National Water Model
NWP	Numerical Weather Prediction
PDA	Pancheshwar Development Authority
QPF	Quantitative Precipitation Forecast
RBA	Rashtriya Barh Aayog
RBO	River Basin Organization
RCC	Reinforced Cement Concrete
RMBA	River Management Activities and Works related to Border Areas
RTU	Remote Terminal Unit
SDMA	State Disaster Management Authority
SDRF	State Disaster Relief Fund
STAC	State Technical Advisory Committee
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UC	Utilization Certificates
WIMS	Water Information Management System

Details of the Committee constituted for formulation of strategy for Flood Management Works in entire country and River Management Activities and works related to Border Areas (2020 – 23)

On the instruction of the Prime Minister's Office (PMO), a Committee was constituted to develop the strategy for flood management for next three years. It was instructed that the strategy should have clear priorities, costs and deliverables for next three years.

Members of the Committee

1.	Vice-Chairman, NITI Aayog	Chairman
2.	Member, Water and Agriculture, NITI Aayog	Member
3.	CEO, NITI Aayog	Member
4.	Secretary, Department of Water Resources, RD & GR, Ministry of Jal Shakti	Member
5	Secretary, Department of Space	Member
6.	Additional Secretary (Border Area Management), Ministry of Home Affairs	Member
7.	Joint Secretary, Ministry of External Affairs	Member
8.	Member Secretary, National Disaster Management Authority	Member
9.	Commissioner, Flood Management Programme, Department of Water Resources, RD & GR, Ministry of Jal Shakti	Member
10.	Member (River Management), Central Water Commission,Sewa Bhavan, Sector 1, RK Puram, New Delhi	Members
11.	Principal Secretaries (Irrigation) of Governments of Jammu & Kashmir, Uttar Pradesh, Bihar, West Bengal, Punjab, Assam, Arunachal Pradesh, Tripura, Madhya Pradesh and Kerala	Members
12.	Director, Central Water and Power Research Station, Pune	Member
13.	Prof. Deepak Khare, Department of Water Resources Planning and Management, IIT-Roorkee	Member
14.	Dr. Sharad K. Jain, Director, National Institute of Hydrology, Roorkee	Member
15.	Dr. (Prof.) Biswa Bhattacharya, Hydro-informatics, IHE Delft Institute for Water Education, Delft, The Netherlands	Member
16.	Adviser, Water Resources, NITI Aayog	Member Secretary

Terms of Reference of the Committee

1. Chalking out Strategy with clear priorities, costs and deliverables for flood management in the country and river management activities and works in border areas, for the years 2020-2023.
2. Devise strategy for urban flood and flash flood mitigation, preparedness and management.
3. Undertake the assessment of impact of climate change on probability of floods in the country.
4. To enlist the priorities, which are deconstructed clearly into medium term and short term measures over the next three financial years along with funding requirements and its mechanics, timelines and deliverables.
5. Suggest policy interventions required for optimally addressing the problem of flood management and river management activities and works in border areas.
6. Identification of various mechanisms / technological interventions / institutional arrangements for flood management and river management including state-of-the-art space technology for designing mechanisms for early warning for floods and other river management works.
7. To make a framework to identify inter-sectoral and inter-ministerial issues and arrive at an action-plan for solving the same.
8. Study the best practices followed globally for flood defense, prevention, protection, preparedness and mitigation, and appraise their replicability and scalability in the Indian context.
9. Spell out the strategy for the catchment area treatment works to prevent sediment load into the rivers along with the extent of fund requirement.
10. To work out fund requirements scheme-wise and state-wise as per the priority.

Executive Summary

Flood is the most recurrent natural calamity and its high time that we should formulate and implement sustainable mitigation measures. The effective and long-lasting strategy involves combination of - structural and non-structural measures along with the use of modern technology which can alleviate the problem of floods to a great degree. The previous plans/strategies of the government to tackle flood emphasized predominantly on the usage of medium-term measures such as embankments, spurs and channelization of rivers. The long-term structural measures like Dams, Reservoirs, detention basins etc have been used in few cases. The long-term measures should be taken up in the cases where there is compulsion for protection of larger area, population or assets. In majority of the places, less expensive non-structural measures like flood forecasting, flood plain zoning, flood proofing etc should be adopted to accommodate high spat of water. The room of the river should be provided by taking up the measures like creating wetlands, lakes and check dams. The construction of embankments/levees should be taken up as the medium-term measures to provide protection to the railway lines, national highways, valuable assets or international boundary. The medium-term measures should be used after the detailed study of river morphology for the entire length of river stretch so as to avoid erosion at one bank and aggradation at another bank or subsequent erosion on upstream and aggradation on downstream and vice versa. Therefore, construction of embankments should be taken up only after the detailed study of the basin.

The committee is of the view to provide priority to non-structural measures to mitigate the floods and shall go for long term and medium-term structural measures when and where those are unavoidable. Aayog also like to emphasize the use of advanced technology like artificial intelligence, satellites, remote sensing and GIS for flood forecasting and warning systems. The committee proposes National Water Model for India which can be built with the help of some scalable models. These models can be used together to feed the information into a decision support system which can provide support services to Nation by predicting precipitation and forecasting flood and other water related events.

The committee has also proposed to extend the Flood Management and Border Area Programme (FMBAP) for the period of 2021-26, co-terminus with the period of 15th Finance Commission with the provision of inclusion of new projects for funding under the scheme. Keeping in view the persistent demand from States to include new schemes under central funding, as no new projects have been included for central funding since the year 2015, the proposed outlay of the FMBAP Scheme for the period 2021-26 shall be around Rs. 15,000 Crores. Some changes like revisions in

monetary limits for appraisal of flood control schemes etc have been suggested in the scheme for its successful implementation.

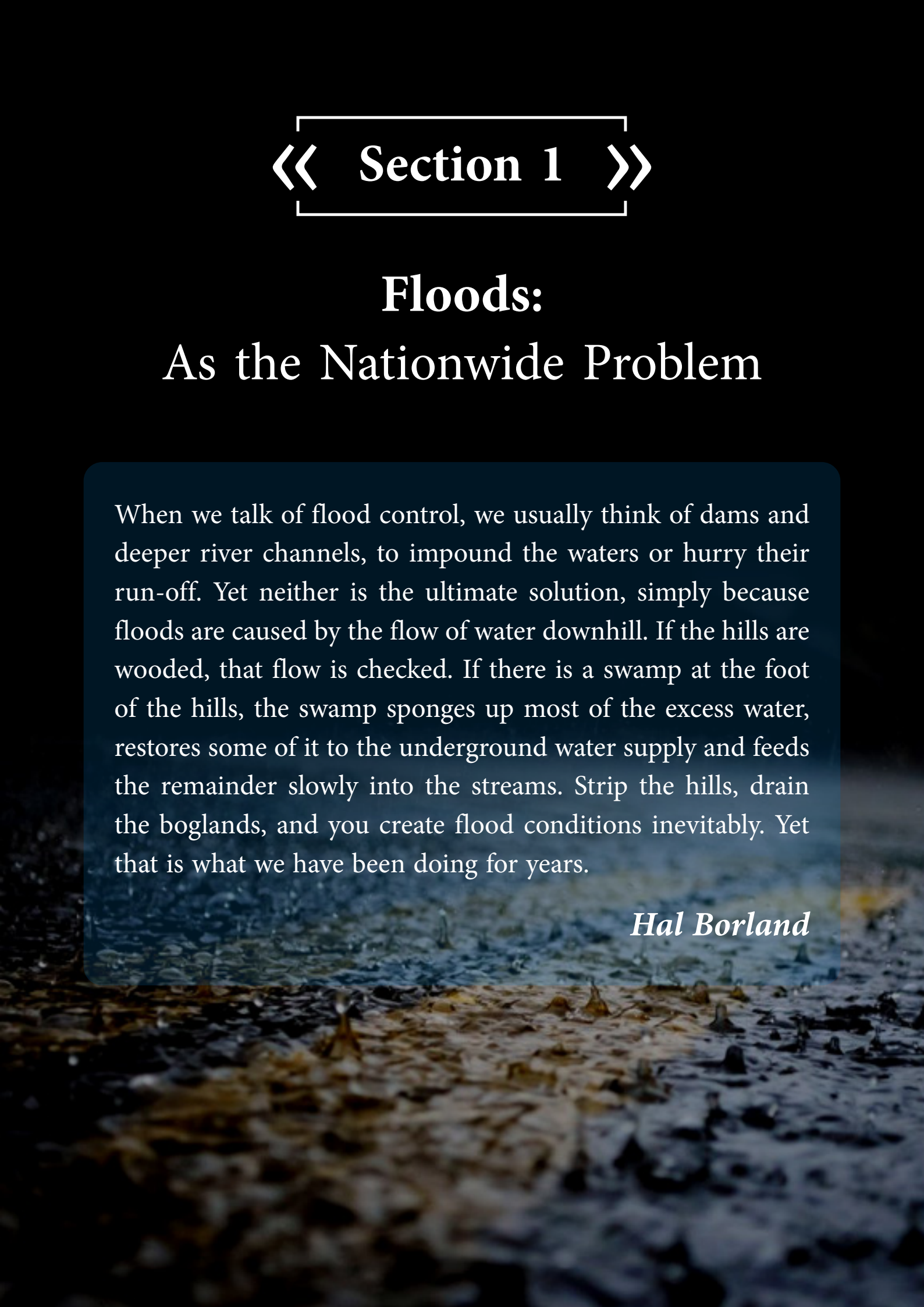
The committee has also advocated the formation of Flood Management Plans which can also help in rescue and relief works during and after the floods. Aayog also proposes for the policy to provide flood cushion in the existing dams to accommodate peak time flood so that the tragedy like Kerala floods doesn't repeat itself.

« Section 1 »

Floods:
As the Nationwide Problem

When we talk of flood control, we usually think of dams and deeper river channels, to impound the waters or hurry their run-off. Yet neither is the ultimate solution, simply because floods are caused by the flow of water downhill. If the hills are wooded, that flow is checked. If there is a swamp at the foot of the hills, the swamp sponges up most of the excess water, restores some of it to the underground water supply and feeds the remainder slowly into the streams. Strip the hills, drain the boglands, and you create flood conditions inevitably. Yet that is what we have been doing for years.

Hal Borland



Introduction

Flood is the most prevalent and costliest natural disaster in the world which devastates both life and economy on large extent. It is defined as, "High-water stages in which water over flows its natural or artificial banks onto normally dry land, such as a river inundating its floodplain." India receives major rainfall in four months spanning from June to September. Distribution of rain across India is dissimilar as some areas receive heavy rainfall while some are at deficit. The variation also varies time to time; the areas which are not traditionally prone to floods also experience severe inundation due to downpour and cloud bursting. Urban flood has become one of the major problems now a days, the recent floods in Kerala, Uttarakhand and in metropolitan cities like Delhi, Mumbai, Kolkata point towards the need for proper management of floods and the drainage system.

The Rashtriya Barh Ayog (RBA) estimated the total area liable to floods in the country as 40 Million Hectare (Mha). The extent of maximum area affected by floods in any year during 1953-2010 as per the Report of Working Group on Flood Management and Region-Specific Issues for XII Plan is 49.815 Mha[1]. Out of it, nearly 21 Mha can be provided with reasonable degree of protection. Based on the statistical details available so far, it has been estimated that annually 7.17 mha. of area is affected with floods of which 3.94 mha. is cropped area. On an average, floods claim 1654 human and 618248 cattle life annually. Around 1.2 million houses are damaged by floods and the average annual losses in monetary terms came to the tune of Rs 5649 crores[2].

India faces floods almost every year, in varying degrees of magnitude. The frequent occurrence of floods can be attributed to factors like wide variations in rainfall both in time and space with frequent departures from the normal pattern, inadequate carrying capacities of rivers, river bank erosion, degradation of hilly catchment and silting of river beds, landslides, poor natural drainage in flood prone areas, glacial lake outbursts, cloud burst, etc. The country suffers huge economic loss annually besides the loss of precious human lives due to floods. There are evidences of increasing number of high intensity rainfall event in the recent years varying non-uniformly in space and time. Such events lead to flash floods. Urban flooding due to storm water drainage congestion (pluvial in nature) has also become common in towns/cities due to such extreme meteorological events. The devastation caused due to floods in the past has drawn attention of the planners of the country towards comprehensive flood management plans, policies and implementation thereof.

Table 1: Flood Prone Areas in India

S.no.	Particulars	Area
1.	Flood Prone Area by Rashtriya Barh Ayog (RBA, 1980)	40 Mha
2.	The extent of maximum area affected by floods in any year during 1953-2010 as per the Report of Working Group on Flood Management and Region-Specific Issues for XII Plan	49.815 Mha

1 Report of Working Group on Flood Management and Region-Specific Issues for XII Plan 2011.

2 CWC Database.

3.	Annually affected Area	7.17 Mha
4.	Annually affected Cropped Area	3.94 Mha
5.	Area provided reasonable degree of protection	21 Mha
6.	Target area to provide reasonable degree of protection by 2035	35 Mha (additional 14 Mha phased in 15 years: 4+5+5)

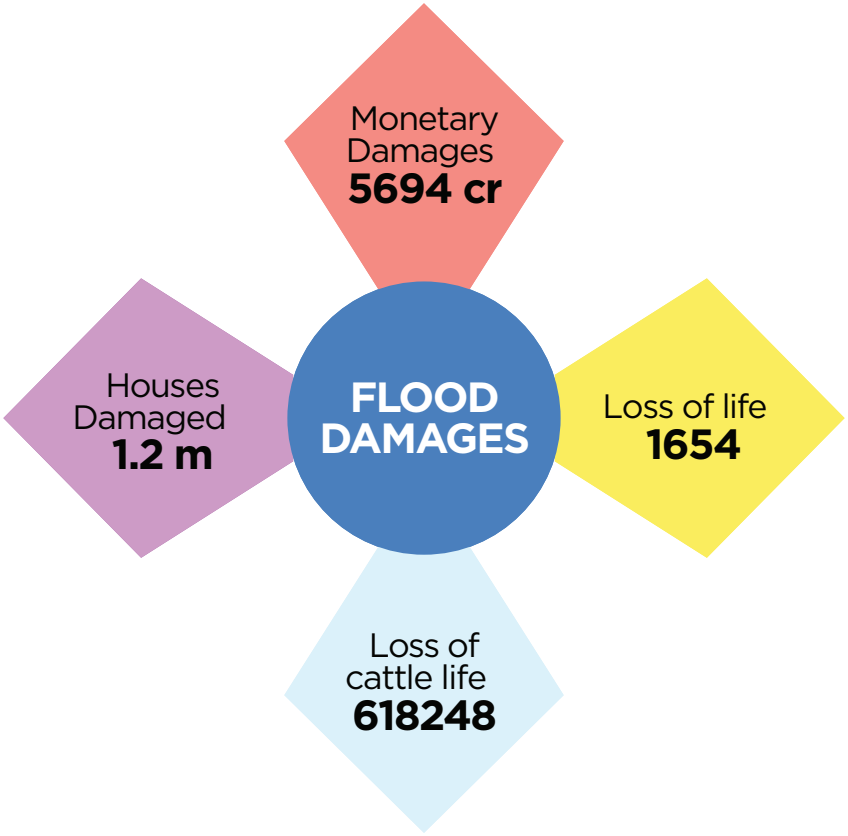


Figure 1: *Average Annual Damage due to flood (1953-2018)*

Flood prone states

The Ganga-Yamuna basin states of Haryana, Himachal Pradesh, Uttar Pradesh, Bihar, West Bengal are prone to floods. Also, Assam gets affected due to floods in Brahmaputra river. The delta parts of river basins of Mahanadi (in Odisha), Godavari, Krishna, Pennar (In Andhra Pradesh), Narmada, Sabarmati and Tapti basin areas in Gujarat are identified as prone to floods. However, of late, the upper reaches of river basins of Krishna, Godavari caused severe floods in the states of Karnataka and Maharashtra. Even states like Kerala received significant rainfall in 2018 causing widespread floods and damage to life and property in almost entire state. The peninsular India faces flood situation during the retreating NE monsoon cyclones during October-November.

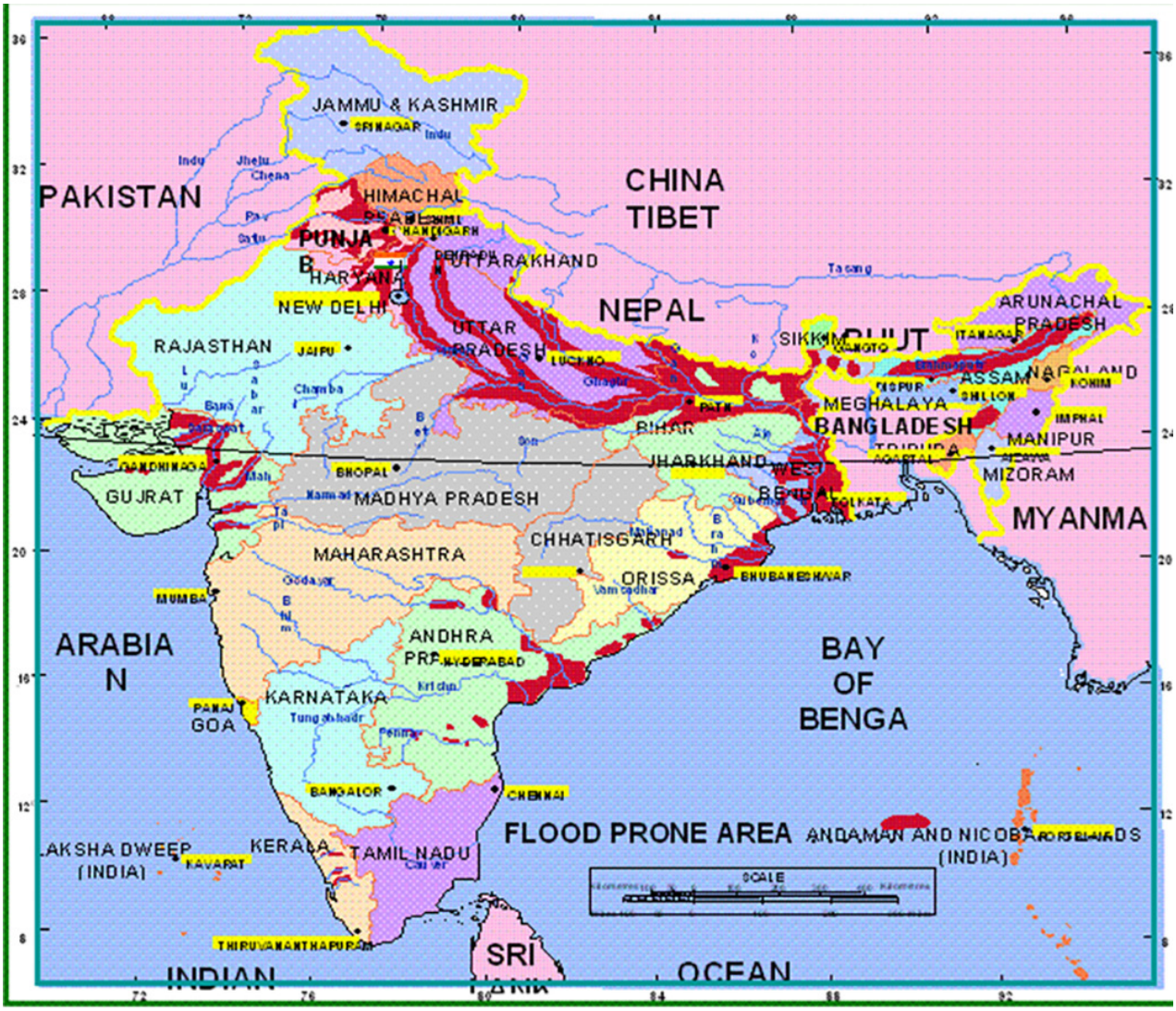


Figure 2: *Flood Prone Areas in India*

Source: *WRIS- The state of J&K is now divided into UTs of J&K and Ladakh. The state of Andhra Pradesh is divided into Telangana and Andhra Pradesh.*

Constitutional Position

As per constitutional provisions, the subject of flood management including erosion control falls within the purview of the States. The flood management and anti-erosion schemes are planned, investigated and implemented by the State Governments with own resources as per priority within the State. The Union Government only renders assistance to States which is technical, advisory, catalytic and promotional in nature.

The subject of flood control, unlike irrigation, does not figure as such in any of the three legislative lists included in the Constitution of India. However, drainage and embankments are two of the measures specifically mentioned in Entry 17 of List II (State List), reproduced below:

"Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to the provision of entry 56 of List I (Union List)."

Entry 56 of List I (Union List) read as follows:

"Regulation and development of inter-State rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest."

It may be seen that the primary responsibility for flood control lies with the States. A number of States have already enacted laws with provisions to deal with matters connected with flood control works. However, there exists a significant provision that the powers to be exercised are subject to Entry 56 of Union List. It may be pointed out that Entry 17 of List II (State List) quoted above does not cover land use involved in the administrative measures of dealing with reduction of flood losses viz. flood plain zoning.

Approach to Flood Management in The Country

The flood management practices have largely focused on reducing flooding and reducing the susceptibility to flood damage through variety of interventions. Different measures have been adopted to reduce the flood losses and protect the flood plains. Depending upon the nature of work, flood protection and flood management measures are broadly classified as under: (a) Structural Measures (b) Non-Structural Measures

Structural Measures for Flood Management: The structural measures for flood control which bring relief to the flood prone areas by reducing flood flows and attenuating the flood levels are:

a. A reservoir created behind a dam across a river

b. A natural depression suitably improved and regulated, if necessary

c. By diversion of a part of the peak flow to another river or basin, where such diversion would not cause appreciable damage.

d. By constructing a parallel channel by-passing a particular town/reach of the river prone to flooding.

The structural methods of flood protection/anti erosion, which do not reduce the flood flow but reduce spilling are:

a. Embankments which artificially raise the effective river bank and thereby prevent spilling.

b. Channel and drainage improvement work, which artificially reduce the flood water level so as to keep the same, confined within the river banks and thus prevent spilling.

c. Anti-erosion measures which prevent further loss of valuable land.

d. River channelization works to train the braided rivers to flow in a desired course to prevent further loss of land and to induce siltation.

Non-Structural Measures for Flood Management: The non-structural measures to mitigate adverse impact of floods involve the following:

a. Disseminating advance warning of incoming flood through a flood forecasting system and facilitating timely evacuation of the people to safer grounds.

b. Discouraging creation of valuable assets/settlement of the people in the areas subject to frequent flooding i.e. enforcing flood plain zoning regulation.

Urban Floods

Increasing trend of urban flooding is a universal phenomenon and poses a great challenge to city administration and urban planners the world over. Problems associated with urban floods range from relatively localized incidents to major ones, resulting in cities being inundated from a few hours to several days. Therefore, the impact can also be widespread, including temporary relocation of people, damage to civic amenities, deterioration of water quality and risk of epidemics. The problems posed by urban flooding are quite challenging and aggravate with continuous climate change, with its adverse impact affecting variation in rainfall and intra-city / intra-region disparities in the distribution of rainfall. Unplanned development and encroachments by sprawling habitations alongside rivers and watercourses have meddled with the natural streams and watercourses. As a result of this, the runoff has increased in proportion to urbanization of the watersheds causing urban floods. In recent years, the challenges posed by Urban Floods coupled with rapid urbanization and climate change requires altogether different approach in comparison to riverine floods. National Disaster Management Authority (NDMA) has brought out detailed guidelines for management of urban floods to boost the efforts for urban flood disaster management and strengthen the national vision of moving towards a more proactive pre-disaster preparedness and mitigation centric approach. These guidelines contain all the details that are required by planners and implementers and help Central Ministries/ Departments and the States/ UTs in preparing the plans. The guidelines are attached as Annexure VIII of the report. In order to check the threat of urban flooding, each city should have their Flood mitigation plans (floodplain, river basin, surface water, etc.) amalgamated with the overall land use policy and master planning of the city.

Impact of Climate Change on probability of flood

Impact of climate change can be witnessed largely in every sector of the economy leading to huge social, environmental and economic losses. Besides, scientists and environmentalists, local people have also started experiencing wrath of climate change. Frequent and unexpected flooding is one of the worst tangible outcomes of climate change. Climate change has intensified the occurrence of natural events by modifying the amount, the distribution and the timing of precipitation, aggravating the incidences of floods in both coastal and land locked regions.

Broadly, climate change can exacerbate the flood situation in two-fold manner:

1. Sea level rise due to melting of glaciers can submerge coastal areas of country degrading fresh water resources due to sea water intrusion, destroying coastal communities and impairing economy while affecting agriculture, industry and tourism sector.

2. Variation in intensity of rainfall: The climate change has caused to increase the frequency of short duration heavy rainfall leading to higher water run-off. It has been observed that due to global warming, increasing temperatures can result into increase in total rainfall coupled with simultaneous decrease in rainy days. Moreover, the steady rainfall with distributed rainy days may get replaced by flashy and momentous rainfall adding large amount of water in a short span of time leading to a disaster.

Natural Disasters always have a huge economic cost attached to it wherein it has also been seen that floods are the most economically damaging climate impact. As per the report published by Asian Development Bank, floods account for more than half of climate-related disasters in India and cause damages of $54.63 billion during 1990–2017. Furthermore, the worst flood of Kerala in 2018 led to the estimated losses of US$ 4.25 billion displacing over 8,00,000 people in the region. Besides this, it has also been estimated that one percent increase in floods can reduce economic growth by 2.7%. Hence, the rising intensity of floods due to climate change calls for urgent need for government functionaries to be well prepared to handle the aggravated situation of flood in the country.

The structural and non-structural measures should be considered meticulously to get prepared for flood like situation in the country. Maintaining the flood plain zones, reviving the urban wetlands, effective storm water management are few of these measures to be considered.

Pragmatic Approach for Flood Management in Country

Providing absolute protection to all flood prone areas against all magnitude of floods is neither practically possible nor economically viable. Such an attempt would involve stupendously high cost for construction and operation & maintenance. Hence a pragmatic approach in flood management is to provide a reasonable degree of protection against flood damages at economic cost through a combination of structural and non-structural measures. The State/UT Governments have largely focused on the structural measures through their investments on flood management works, anti-erosion, anti-sea erosion, drainage development and maintenance works commensurate to the problems faced by them. Such works are implemented through the State WR/Irrigation/Flood Control/Public Health Departments. Govt. of India under Flood Management Programme (FMP) has been providing promotional financial assistance to States for such works in critical areas subject to budgetary allocations. Govt. of India has also been contributing through the non-structural measure of flood forecasting and warning on inter-State rivers which is less capital-intensive and has enabled the State Governments to take advance action/ measures to save valuable life and property. The Flood Management Programme (FMP) with an outlay of Rs. 8,000 crores were implemented by the Government of India in XI Five Year Plan to provide financial assistance to States/UTs in implementing flood management projects. The Scheme was continued with outlay of Rs. 10,000 crores during XII Plan. Another scheme “River Management Activities and Works related to Border Areas (RMBA)” was started in XI Plan with an outlay of Rs 820

Cr and was continued in XII Plan also with an outlay of Rs 740 Cr for taking up of different works in Border areas. Both the schemes were merged as Flood Management and Border Areas Programme (FMBAP) and continued for the year 2017-20 with merged components.

Inter-sectoral Contribution

Aftermaths of flood are struck across different sectors. By means of the flood protection measures transportation network, power-transmission lines, amenities of civic communities and the bio-diversity in forest and non-forest land are saved from the peril. The custodian agencies of such sectors may be encouraged to earmark some budgetary allocations towards the flood management initiatives, which will be instrumental in ensuring cross-sectoral involvement.

Section 2

Structural and Non Structural Measures for Flood Mitigation

Structural Approach

The traditional approach to flood management is to decrease the intensity of flood peak by holding or diverting a part of inflows or increasing the capacity of stream to enable passage of flood peak without spilling. The structural measures of flood management are aimed to keep the floods away from the people and several structural approaches for flood management are discussed in succeeding paragraphs.

1. **Reservoirs:** Reservoirs can moderate the intensity and timing of the incoming floods. They store water during periods of high discharges in the river and release it after the critical high flow condition is over, so as to be ready to receive the next wave of floods. Their effectiveness in moderating floods would depend on the reservoir capacity available at that time for absorbing the flood runoff and their proximity to the likely damage centre. They are operated with a carefully planned regulation schedule which takes into account both the safety of the dam and related structures and the safe carrying capacity of the lower reaches of the river in their present condition. Reservoirs are more effective for flood management if, apart from the incidental moderation available for any type of storage on a river, specific flood cushion is earmarked, as in the case of DVC dams across the Damodar and its tributaries. A solution to floods lies in construction of large storage reservoirs which moderate flood peaks by adopting appropriate reservoir operation schedule. However, the construction of large reservoir have many challenges and constraints like topographic, geological, geographical, environmental, submergence, interstate & international issues, long gestation period, water sharing etc.

   Government of India has been regularly interacting with the Government of Nepal for construction of dams on the cross border rivers flowing from Nepal to India for mutual benefit of the two countries which includes flood control. Survey and investigation including preparation of DPRs of Sapta Kosi High Dam Project and Sun Kosi Storage cum Diversion scheme proposed in the Sapta Kosi basin in Nepal along with Kamla (tributary of Kosi) and Bagmati (tributary of Kosi) has been undertaken jointly by India and Nepal. Pancheshwar Development Authority (PDA) has been set up jointly by India and Nepal for execution, operation and maintenance of the Pancheshwar Multipurpose Project on river Sharda. The projects will provide significant flood control benefits to the states of Uttar Pradesh and Bihar and their implementation need to be fast tracked. In order to mitigate Brahmaputra flood, flood storage is essential in Subansiri, Siang, Dibang and Lohit sub basins. Several projects have been identified in these sub-basins. However, except for Lower Subansiri Project, not much progress has been achieved on ground in respect of identified projects. As per a study by CWC, in order to mitigate Brahmaputra flood at Pandu, Guwahati, from 22 lakh cusec to 14-15.5 lakh cusec (reduction in level by 1.25 to 1.6 m) aggregate flood storage of the order of 13.30 BCM would be required in various sub-basins. In order to mitigate Barak flood, flood storage is also essential in Barak basin. There is an urgent need to expedite implementation of these identified

projects. The National Water Policy (2012) emphasize that all water resources projects, including hydro power projects, should be planned to the extent feasible as multipurpose projects with provision of storage to derive maximum benefit from available topology and water resources.

2. **Detention Basins/ Wet Lands:** Detention basins are usually formed by utilizing natural depressions/ swamps and lakes by improving their capacity by constructing encircling embankments and providing suitable devices for regulating the release of stored waters. Since, the land under the marshes or low depression may hardly require much compensation and rehabilitation measures, this method is relatively inexpensive. The Ghaggar detention basin in Rajasthan is a good example. Depressions available upstream of Srinagar City, on the left bank of river Jhelum, the Mokama Tal area in Bihar and Ottu, Bhindawas, Kotla lakes in Haryana and various beels/ haors of Barak basin are some examples of natural basins. It has been observed that in view of growing pressure on land resources, particularly in and around urban areas, there are cases where naturally occurring detention have been encroached upon or their path obstructed. To get benefit of flood control, it is essential that such tendencies are curbed and the basins are restored to their natural state. Integration of such Detention basins/Wetlands with other structural measures in form of embankments, cross drainage works in form of sluices etc. may be beneficial for managing floods in an efficient manner.

3. **Embankments:** Embankments (including ring bunds and town protection works) confine the flood flows and prevent spilling, thereby reducing the damage. These are generally cheap, quick and most popular method of flood protection and have been constructed extensively in the past. These are reported to have given considerable protection at comparatively low costs, particularly in the lower reaches of large rivers. The raising and strengthening of existing embankments have also been taken up in many of the flood prone States. In order that this work is done adequately it is necessary to adopt the flood frequency approach in their redesign, taking into account the data of historical floods, which is now available. Efforts of the State Governments have so far been concentrated mostly on undertaking these measures like raising & strengthening of the existing embankments, and also construction of new embankments. During XI and XII Plan period with Central assistance under Flood Management Programme (FMP) of Ministry of Jal Shakti, State Governments have taken up several projects for construction of embankments. So far State Governments have built 37073 km length of embankments in the country which includes projects undertaken from their own resources till March, 2017. The efforts in this regard may need to be continued in the times to come, as per site specific requirement.

4. **Channelization of Rivers:** Some of the States are proposing channelization of rivers, at least in certain reaches, in the context of tackling the extensive meandering problems of the rivers, activating navigational channels and training these rivers into their original

courses by means of constructing embankments on both banks. As the river Brahmaputra and some of its tributaries are very much braided in nature, the State of Assam is taking up river channelization and dredging measures for training the oblique channels for preventing severe erosion. While venturing to channelize rivers, thought must be given in allowing the river certain freedom to flow and right of way to pass its flood waters and silt load within its natural waterway. The dynamic nature of the rivers should be appreciated and preventive measures planned accordingly instead of pinning down the river by channelizing.

5. **Channel Improvement:** The method of improving the channel by improving the hydraulic conditions of the river channels by desilting, dredging, lining etc., to enable the river to carry its discharges at lower levels or within its banks has been often advocated but adopted on a very limited extent because of its high cost and other associated problems. Dredging operations of the Brahmaputra, which were undertaken in the early seventies on an experimental basis, were discontinued because of their prohibitive cost and limited benefits. The issue of dredging/de-silting of rivers has been studied by various experts/ Committees and it has been opined that de-silting/dredging in general is not feasible technically, due to several reasons like non-sustainability, cost effectiveness, non-availability of vast land required for the disposal of dredged material, etc. Dredging in selected locations may perhaps be considered as a component of a package of measures for channel improvement to check the river bank erosion subject to techno-economic justification. It may be economically justifiable as a method for channel improvement where navigation is involved. Dredging is sometimes advocated for clearing river mouth or narrow constrictions.

6. **Drainage Improvement:** Surface water drainage congestion due to inadequacy of natural or artificial drainage channels to carry the storm water discharge within a reasonable period causes inundation and damages. It is often difficult to distinguish between flood and drainage congestion situations. This problem is rather acute in Andhra Pradesh, Bihar, Haryana, Punjab, Orissa, Uttar Pradesh, Assam and West Bengal. Therefore, improvement of drainage by construction of new channels or improvement in the discharge capacity of the existing drainage system is recommended as an integral part of the flood management programme in the country. The adequacy of existing sluices and drainage channels should be reviewed in areas suffering from drainage congestion. If the capacities of existing sluices in embankments and drainage channels are inadequate, this should be improved by increasing the vents and improving outfall conditions. Drainage improvement and embankment together have resulted in protecting area of about 20.54 Mha from floods.

Lower Subansiri Project

Mokama Tal area in Bihar

Before Channelization

After Channelization

Green Method for Flood Control

Groynes

Figure 3: *Various Structural Methods for Flood Control*

7. **Diversion of Flood Waters/ Interlinking of Rivers:** Diversion of flood waters as a flood control measure involves transfer of a part of the flood discharge to another basin or to the same basin downstream of the problem area or to a depression where it could

be stored for subsequent release. This measure can be used to manage unusual floods around cities as in the case of flood spill channel near Srinagar and also in the lower reaches of a river near the sea as in the case of Krishna Godavari drainage scheme. The projects for interlinking of rivers for diversion of flood water to water scarce areas may be taken up in a time bound manner. Large dams and canal systems are proposed to be constructed for storage and transfer flood waters of the surplus river in inter basin water transfer proposals. NWDA has identified 30 inter-basin transfer links (16 under Peninsular component and 14 under Himalayan components).

8. **Watershed Management:** The watershed management measures include developing and conserving the vegetative and soil covers (Catchment Area Treatment) and also to undertake structural works like check-dams, detention basins, diversion channels, etc. In the watershed management of upper catchment, land treatment through afforestation and grass land development practices should be supplemented by structural works for retarding the water velocity and arresting silt. By proper management of watershed, silt carried and deposited in the lower reaches of rivers can be reduced, leading to better carrying capacity of the channel and thus serves as an effective flood control measure. Catchment Area Treatment measure may be termed as **Green Measures for flood management**. The treatment involves understanding of the erosion characteristics of the terrain and identifying/ suggesting remedial measures to reduce the erosion rate. It is also considered as soft engineering measures for reducing the silt load in river thereby increasing the discharge carrying capacity of the river and hence protection against flood. Generally, it deals with vegetation growth in catchment area to hold soil from erosion. Watershed management works in the hilly catchments of the rivers originating in Nepal, Bhutan as well as in hilly areas of India should be selectively chosen and funded through central assistance. Nodal Ministry viz Ministry of Rural Development, Department of Land Resources for the watershed management works may work out a detailed programme in consultation with Ministry of Jal Shakti, other stake holders and State Governments.

9. **Anti-Erosion Works:** Alluvial rivers are characterized by meandering from one bank to another. It erodes constantly materials from concave bends and deposits between two successive bends or deposits along the convex banks of successive bends. The flow pattern along its path changes considerably from flood to flood. River bank erosion leads to loss of valuable land and related socioeconomic problem. Rivers in flood plain can be aggrading, degrading or stable depending upon silt deposition or erosion. A variety of factors play a major role in causing bank erosion. These parameters among others include river curvature, reverse / cross flows, composition of bed / bed material etc. Anti-erosion works in the form of bank revetment, spurs, porcupines (RCC or bamboo porcupines) etc. are provided to manage/control the floods, to check the bank erosion. Measures in form of bamboo porcupines may be termed as green structural

measures. Now–a-days, new innovative materials like Geo-textile in the form of Geo-textile bags, Geo-textile tubes, Sand filled Geo-mattress, Neo-web, submerged vanes and RCC porcupines are being increasingly used in construction of revetments, spurs, groynes, embankments etc. These materials are used due to their unique characteristics like durability, resistance to chemical waste, environment friendly nature, easiness in installation etc. Recent developments have found that riparian vegetation interacts with a range of geomorphological, geotechnical, hydrological and hydraulic factors to affect the type and extent of riverbank erosion. In this regard, special vegetation like vetiver grass on river banks have been found to be helpful in checking erosion. These measures may be termed as Green Measures for bank protection. The vetiver is a special type of grass having longer roots length with high tensile strength and is thus resistant to the high velocity streams and checks the erosion. However, such type of grass needs replacement after flood season, in case of silt deposition over the grass. The enhanced lateral channel stability offered by well-vegetated riparian zones can also reduce the need for engineered stabilization and heavy maintenance.

10. **Coastal Erosion:** The coastline of country extending from West Bengal to Tamil Nadu in the Bay of Bengal and Kerala to Gujarat in the Arabian Sea is perpetually exposed to erosion of Sea. Indian Coastline has been experiencing erosion problem and around 45.5% percent of coastline is affected by it in varying magnitude. There have been several measures adopted in India to counter the problem of erosion in the form of structural measures such as Sea Wall, revetments, Groynes etc. Their suitability and adverse effects are debatable however it is now increasingly felt world over that soft measures and non-structural measures such as beach nourishment etc, should be employed in conjunction with traditional structural measures while dealing with coastal erosion problem. Coastal Erosion problem is complex effect of various natural processes working in coastal zone and sometimes beyond it. Any intervention to combat erosion requires adequate data in terms of quality and quantity on various processes such as wave, tide, current, wind etc. along with other factors such as bathymetry, beach profile/material etc. Places where rivers are joining sea, poses further challenges in terms of data requirements to account for discharge, silt load etc. In India, data on above aspects are collected by different agencies as per their mandate and requirement and hence coordinated approach is lacking. The issue of Coastal Erosion has been in the focus of Government of India and Beach Erosion Board (BEB) was constituted as early as in 1966 to study the problem along the Kerala Coast which was having severe problem. Later on, it was realized that same program and attention is required for the entire coastline of India and scope of BEB was extended to cover the entire coast. With the objective of the development in the protected coastal zone and the pressure of population in the densely populated areas in the coastal zone, the Beach Erosion Board was reconstituted and rechristened as Coastal Protection and Development Advisory Committee (CPDAC) in April, 1995 with the major objective to

identify and develop the various resource potential available behind the protected areas. Since then, various initiatives have been taken at national level as well as state level to address the problem in a more scientific manner. Coastal Protection and Development Advisory Committee provides a common platform to all concerned maritime States/UTs to discuss issues related to coastal protection and development. The Committee has given its recommendations in the past on various coastal related issues. Government of India has initiated setting up of Coastal Management Information System (CMIS) with an objective to create an integrated data bank to tackle coastal erosion in a scientific manner keeping in view the long-term perspective and collection of data on coastal processes relevant for evolving long term plans and coastal protection measures. The activities related to control of coastal erosion in an integrated manner to provide environmentally and economically acceptable coastal protection system need to be promoted.

Integrated River Basin Management Approach

Integrated flood management calls for a paradigm shift from the traditional, fragmented and localized approach, and encourages the use of the resources of a river basin as a whole. Therefore, there is a need for an approach backed by latest technologies and implemented in a most effective manner. In order to have integrated basin development including flood management in a holistic manner, setting up of River Basin Organisations (RBO) may be expedited by the Central/ State Governments. The River Basin Organizations shall have the mandate to implement flood control measures encompassing immediate, short-term and long-term solutions in an effective manner apart from overall water resources development of the basin

Non-Structural Approach

Integrated flood approach aims at adopting well judicious mix of structural and nonstructural measures. Another dimension to this approach is that flood management works should not be limited to critical reaches only. Rather, the planning should be done at hydrological unit (basin) level. Also, a coordinated effort among different central ministries/ department, state Governments and public is needed as part of integrated flood management.

i. **Flood Plain Zoning:** Flood-plain zoning is a concept central to flood plain management. This concept recognizes the basic fact that the flood plain of a river is essentially its domain and any intrusion into or developmental activity therein must recognize the river's 'right of way'. Flood-plain zoning measures aim at demarcating zones or areas likely to be affected by floods of different 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. Although, this approach is generally endorsed by all in principle, scant attention is given to it in actual practice, leading to increased flood damages. Ministry of Jal Shakti has continuously impressed upon the states about the need to take action to implement the flood plain

zoning approach. A model draft bill for flood plain zoning legislation was also circulated by the union government in 1975 to all the states. The state of Manipur had enacted the flood plain zoning legislation way back in 1978 but the demarcation of flood zones is yet to be done. The state of Rajasthan has also enacted legislation for flood plain management in the State but enforcement thereof is yet to be done. The Government of Uttarakhand has enacted the Flood Plain Zoning Bill in December 2012 and has notified limit of Flood Plain Area in two reaches viz. Haridwar (Chandi ghat to Laskar) and Uttarkashi (Gangori to badethi Chungi). Other States are yet to take action for enactment of legislation. Enactment and enforcement of Flood Plain Zoning regulations should be one of the priority areas for which provisions of Disaster Management Act, 2005 can also be relied upon. The States/UTs are to be encouraged to complete the hydrologic and hydraulic modeling for flood mapping in time bound manner.

ii. **Flood Forecasting:** Flood forecasting is considered as one of the most cost effective non-structural measure for flood management. The work of flood forecasting and warning in India is entrusted to the Central Water Commission (CWC). Flood Forecasting and flood warning in India commenced in a small way in the year 1958 with the establishment of a unit in the Central Water Commission (CWC), New Delhi, for flood forecasting for the river Yamuna at Delhi. Presently, there are around 1600 Hydro-meteorological sites being operated by CWC across the country covering 20 river basins for gauge, discharge, sediment & water quality observations. Many of these stations are used as flood monitoring stations for formulating flood forecasts. The activity of flood forecasting comprises of Level Forecasting and Inflow Forecasting. The level forecasts help the user agencies in deciding mitigating measures like evacuation of people and shifting people and their movable property to safer locations. The 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. Presently, Flood forecasts are issued by CWC at 325 stations (128 Inflow Forecast Stations + 197 Level Forecast Stations) as per Standard Operating Procedure. Annually, about 7000 flood forecasts are issued by CWC during floods.

   a. **Modernisation of Data Collection and Transmission System:** CWC had planned for installation of real-time data acquisition system for 968 stations in various river basins. There is a proposal to increase the coverage by another 125 stations under 14th Finance Commission period for which work is in progress. Another 100 stations are also planned to be added by 2025 taking the total automatic sensor-based data acquisition and satellite-based data transmission to around 1193 stations. In addition to 1193 stations to be established by CWC by 2025, IMD is also planning to expand its Automatic Weather Station (AWS)/ Automatic Rain Gauge (ARG) Network which can also be utilised by mutual sharing for use in Mathematical

models for flood forecast. In addition, under National Hydrology Project (NHP) many of the State Governments are also installing automatic telemetry-based water level/reservoir level and rain gauge sensors in various river basins within their State. These data are also likely to be available through Water Information Management System (WIMS)/National Water Information Centre (NWIC) portal. All these stations can be utilised on real-time basis for use in mathematical modelling for flood forecasting. This will increase the coverage of Hydro-meteorological data network significantly in the country during the coming years for real-time use in flood forecasting. Further, simplified data dissemination policy for use of data by the States particularly regarding trans-boundary rivers needs to be developed.

b. **Advancements in Flood Forecast Formulation:** During the early period of flood forecasting activity upto 1958 to 1990s, conventional flood forecasting models using Statistical correlation and regression equations were used to formulate flood forecast. During 1990s, the data entry systems were modernized using data processing software such as spreadsheets and Tables. Spreadsheets were also used to generate correlation and regression equations. During the X Plan period, tools like Mike-11 software were adopted for telemetry modelling centres established. During XII Plan, all the new flood forecasting stations which were operationalised were also brought under mathematical modelling. New Mike-2016 software was utilised during XII Plan. Three-days advance advisories for flood were started from 2017 onwards and are now available for all the 325 flood forecasting stations. In this regard CWC has entered into an understanding with IMD for getting their data seamlessly. IMD has started sharing Numerical Weather Prediction (NWP) model outputs and is also providing map based sub-basin-wise Quantitative Precipitation Forecasts (QPFs) from 2017 onwards. In view of several instance of flash floods being faced in recent times in the country, there is a need to develop flash flood forecasting and early warning system. Flash floods are attributed to favourable combination of meteorological and hydrologic conditions along with characteristics of catchment area. Focus on scientific research in development of Model based system to forecast flash flood with sufficient lead time will provide a much-needed relief from menace of flash floods.

c. **Modernisation of Forecast Dissemination:** CWC is maintaining a web-based flood forecasting web site since 2006 which was upgraded and made more user friendly from 2014 and is being used till date. This is further being upgraded using Water Information Management System (WIMS) through which better data entry system, report generation and user-friendly web functions are envisaged. CWC is also working in collaboration with M/s Google for generating Common Alerting Protocol (CAP) for sending CWC's Flood Forecasting information to general populace in the affected areas through Google enabled android smart phones or through various

Google platforms from 2015 onwards. National Disaster Management Authority through Centre for Development of Telematics (C-DoT) under MoCIT is also developing its own CAP alert systems through which priority call routing will be given from the concerned mobile towers. Radio and TV broadcast of alerts are also being envisaged. The system is being tested on pilot basis in Tamil Nadu since March 2020 onwards. CWC is also collaborating with M/s Google Inc., to provide inundation alerts based on the Flood Forecast available in CAP platform using high quality Digital Terrain Models available with Google using Artificial Intelligence and Machine Learning. The system started functioning from 2018 when inundation alerts were provided for Patna Gandhighat forecast stations. This has been expanded to around 11,000 sq.km. covering 7 FF stations (Patna Gandhighat & Kahalgaon in Bihar, Neamatighat, Tezpur, Guwahati & Goalpara in Assam and Ayodhya in Uttar Pradesh) during 2019. This is likely to be covered to all level forecast stations during the next few years.

iii. **Reservoir Operation:** Dams in our country are not dedicated for single purpose of flood moderation whose requirement is conflicting in nature to conservational purposes. Most of the large dams in the country are multipurpose with competing demands. Even in the reservoirs having no dedicated flood cushion, incidental benefits of flood moderation can be derived by providing dynamic flood cushion. To meet the objective set forth in planning a reservoir or a group of reservoirs and to achieve maximum benefits out of the storage created, it is imperative to evolve guidelines for operation of reservoirs. Without proper regulation schedules, the reservoir may not meet the full objective for which it was planned and may also pose danger to the structure itself and to the people. Filling of reservoir should generally be slow during initial period of flood season and aggressive filling should be done near the end of flood season. Inflow forecast should also be utilized for real time operation of reservoirs. It helps in pre-emptying the reservoir to avoid flooding like situation downstream. In last few years, dam releases has become an issue as far as flooding in downstream reaches is concerned such as, the Chennai Floods of 2015, Ganga floods in the State of UP and Bihar during 2016, the Ranganadi floods of Assam in 2008 and 2017, Doyang floods of Assam in 2018, Kerala Floods in 2018 and the Krishna Floods in the States of Maharashtra and Karnataka, Chambal Floods in the States of Madhya Pradesh and Rajasthan during 2019. Control of flood is better achieved if the reservoir level is kept low in the early stages of the monsoon season. However, at a later stage, if the anticipated inflows do not realize, the reservoir may not get filled up to Full Reservoir Level (FRL) even upto end of monsoon. On the contrary, if the reservoir is kept at high levels initially to avoid the risk of reservoir remaining unfilled at later stage, there may be problem of accommodating high floods occurring at later stage. Rule curves of major reservoirs, where flood cushion is not in-built, need to

be reviewed to have some dynamic flood cushion for major part of the flood season. In case of extreme meteorological event, the safety of the dams is of paramount importance and releases become mandatory. For reservoirs in series with intermediate inflows and storage serving solely for flood control downstream, it is optimal to regulate floods by filling the upper reservoirs first and emptying the lower reservoirs first. The operation of reservoirs in parallel requires simulation with optimization approach. Some of the essential required actions are:

a. Rule curve/ level for all reservoirs should be prepared & updated accounting change in rainfall trend and changing demand over the years due to rapid increase of population, urbanisation and industrialisation. Rule curves of major reservoirs, where flood cushion is not in-built, need to be reviewed to have some dynamic flood cushion for major part of the flood season.

b. Inflow forecasting and SoP for water release should be made mandatory for all reservoirs.

c. Emergency Action Plan (EAP) for dam break/extreme flood situations should be ready. It will include flood inundation maps and flood waves & time analysis. The list of dams which has prepared the EAPs is attached in Annexure IV of the report.

d. Release information for downstream areas should be provided with adequate response time.

e. Channel encroachment in downstream stretches of a dam should be removed.

iv. Integrated Reservoir Operation (IRO): The Crisis Management Plan (CMP) of Department of Water Resources, River Development & Ganga Rejuvenation (DoWR, RD&GR) includes the provision on Integrated Reservoir Operation (IRO) for flood management. The plan for implementation of IRO for flood management included in CMP involves entry of data by reservoir owners in the State in Water Management Information System (WIMS). The data from reservoirs along with hydro-meteorological data available with CWC as well as those received from IMD including rainfall forecast will be used for running mathematical models for formulating inflow forecast at least 72 hours in advance for the various reservoirs identified in various basins in the plan. Based on the inflow forecast provided and the availability of flood cushion in the reservoir, release advisories shall be issued by Flood Crisis Management Team (FCMT) to be formed in various basins. The FCMT may be headed by the Chief Engineer of the respective Basin Organization of CWC with members from all co-basin States and the Superintending Engineer of CWC Basin Organization will be the Member – Secretary. The FCMT may meet frequently during Flood Crisis and advise the Project authorities within the system of reservoirs regarding the quantum of release so that flood inundation in the downstream areas shall be minimized. However, there is no

mandate to the project authorities to follow the release advisory of FCMT as the release of water from project is in the purview of State Governments. In order to operationalize the concept, mandate in the form of an executive order or a parliamentary act may be needed. This can be brought as an executive order under DM Act 2005 or as a part of the proposed Dam Safety Bill which has since been passed by Lok Sabha and is to be passed by the Rajya Sabha. Based on the type of system, there are single and multi-reservoir systems. Multireservoir systems can be treated as cluster and connected both in series and as parallel units. Furthermore, reservoirs can be classified according to their function as the reservoirs may be for single purpose or multi-purpose reservoirs. Multi-purpose reservoirs serve a combination of functions, including irrigation, hydropower, flood management, fisheries, recreation and tourism. The operation of multi-purpose reservoirs also involves various interactions between these different functions that can lead to conflicting interests. Dam Safety Bill provides for surveillance, inspection, operation and maintenance of the specified dam for prevention of dam failure related disasters and to provide for institutional mechanism to ensure their safe functioning and for matters connected therewith or incidental thereto. The Bill has exclusive provision regarding coordinated reservoir operations of cascading dams.

v. **Dam Safety and Emergency Action Plan (EAP):** Under the Dam Rehabilitation and Improvement Project (DRIP), two relevant and comprehensive Guidelines for dam operation related aspect viz., Guidelines for Preparing Operation and Maintenance Manuals for dams and Guidelines for Developing Emergency Action Plan for dams have been published for guidance of country's dam owners. The Guidelines for Preparing Operation and Maintenance Manuals, CWC, 2018 for dams contain various aspects of project operation including normal operation and emergency operation. These serve as guidance for dam owners on various protocols and responsibilities for managing water releases during a year including flood seasons. Details for preparation of operational rule curve (both for reservoir filling and release) are also part of the guidelines. The Guidelines for Developing Emergency Action Plan for Dams, CWC, 2016 describes all elements of an Emergency Action Plan (EAP) and comprehensively covers requirements for notification flow charts, emergency conditions, inundation maps, emergency detection, evaluation and classification, emergency preparedness and implementation methodologies. The EAP is one of the most important documents to mitigate the associated risks and consequences in case of a dam failure and any other major exigency. Under the Project, this document is being prepared for all DRIP dams, and at the same time Stakeholders Consultation Meetings are being conducted to disseminate provision of this document with all stakeholders and sensitize all concerned agencies as well as public in order to develop more resilience in handling such disasters. So far under the ongoing DRIP project, 176 nos of draft EAPs prepared, and 132 EAPs have been published

and 42 nos of Stakeholder Consultation Meetings conducted. These two protocols will ensure safety and operational performance of dams, will mitigate the associated risks with dam failure through stakeholder's sensitization about consequences and contribute in making more disaster resilience society.

vi. **Application of Space Technology:** Satellite remote sensing has an enormous potential in providing inputs to disaster management. Remote sensing provides a means of quickly visualizing the impact of a natural disaster like floods and make an assessment for prioritizing and taking necessary relief measures in time and space. In addition, space-based communications play vital role in disaster management. Earth observation satellites provide comprehensive, synoptic and multi temporal coverage of large areas in near real-time. The technology can be adopted to provide real-time information on major disasters like floods and cyclones in the following areas; - Near real-time flood mapping due to riverine and cyclonic floods - Damage assessment due to floods and cyclones - Flood progression, recession, and duration studies - River morphometric studies - Spatial flood early warning studies - Preparation of flood hazard maps - Embankment breach studies - River bank erosion studies and efficacy of anti-erosion measures taken up in the river banks. Considering the potential use of space technology in terms of satellite remote sensing and communication in disaster management, Indian Space Research Organization has embarked upon the Disaster Management Support Programme (DMSP) addressing all three disaster phases of preparedness, response and mitigation for Disaster Risk Reduction in the country by through space-based inputs.

    a. Spatial Flood Early Warning Development of spatial flood early warning models using very high-resolution Digital Terrain Models is gaining momentum for giving spatial flood alarm prior to the event. Space based inputs provide very vital information on topography and climate that can be used in developing long range flood early warning models. Considering the requirements at national level and its importance, National Remote Sensing Centre has developed spatial flood forecast models for Godavari and Mahanadi Rivers in association with CWC using space-based inputs. Web-enabled semi-automated Spatial flood early warning models for major floodplains of these two rivers have been developed using high resolution digital terrain models (ALTM DTM) and land use land cover and being run on experimental mode in real-time with other data support from CWC and IMD, and the results are being disseminated. The pilot studies led to the development of fully automated operational spatial flood early warning systems for Godavari and Tapi river basins under National Hydrology Project (NHP).

    b. Near Real-Time Monitoring and Mapping of Floods Space technology has been providing accurate and near real-time information on riverine and cyclonic flooding using its large area and frequent temporal coverage. This Report of information is an

important input for near real-time relief and rescue operations and flood management on the ground. Duration of spatial flooding, flood progression and recession are the other products provided using temporal remote sensing data. Flood damage can be assessed using very high-resolution optical data acquired immediately after the flood events. NRSC works in close coordination with the concerned Central and State Disaster Management authorities including MHA, NDMA, SDMAs, etc and disseminates the satellite and aerial based disaster products for disaster risk reduction in the country.

c. State Level Flood Hazard Atlases using Historic Satellite Data Preparing flood hazard maps is one of the best inputs for non-structural methods of flood damage risk reduction. These maps are useful in planning developmental activities in floodplains, construction of relief, rescue, and health centers, planning flood tolerant crops in floodplains. Satellites provide synoptic observations of the natural disasters at regular intervals that help in disaster risk reduction in the country. As part of disaster mitigation phase, NRSC has taken up major responsibility on the behest of NDMA in preparing State level Flood Hazard Atlases using historic satellite data coupled with ground validation. Flood Hazard Atlases of Assam, Bihar, and Odisha were prepared and released by the concerned States. Preparation of Flood Hazard Atlases of Andhra Pradesh, West Bengal, Uttar Pradesh, and updation of Bihar Atlas are taken up on top priority

vii. Adherence to Coastal Zone Regulations: The regulations stipulated under Coastal Regulations Zone notification 2019, though primarily intended to protect ecologically sensitive coastal stretches, serve the purpose of reducing impact of floods. The prohibition of activities in mangrove areas and in area between High and Low tide lines conveys the clear direction to stay from flood prone belts. Certain ecologically sensitive coastal area of the country is identified as Critically Vulnerable Coastal Area and an Integrated Management Plan (IMP) have to be prepared for such areas. Specific provision restricting new construction within 20 meters from High Tide Line in backwater islands and islands along the main land coast is also included in the notification. Enforcement of the notification using the powers under Environment (Protection) Act 1986 will definitely save a larger community from the avoidable wrath of flooding.

Section 3

Critical Review of Flood Management Works in India and some solutions from International Best Practices

Important Government Initiatives

Since the flood management is primarily in the domain of States, flood control and management schemes are planned, investigated and implemented by the State Governments with their own resources, according to the priority within the States. The Union Government renders assistance to States, which is technical, advisory, catalytic and promotional in nature. The Department of Water Resources, River Development and Ganga Rejuvenation (DoWR, RD&GR), Ministry of Jal Shakti is responsible for laying down policy guidelines and programmes for the development and regulation of the country's water resources. The Ministry provides technical guidance and conducts scrutiny, clearance and monitoring of the irrigation, flood control and multi-purpose projects (major/medium). The Ministry is also responsible for operation of the central network for flood forecasting and warning on inter-state rivers, the provision of central assistance for some State Schemes in special cases and preparation of flood control master plans for the Ganga and the Brahmaputra. The two-tier system for flood management in India is:

Central Government

- Central Water Commission
- Ganga Flood Control Commission (GFCC)
- Brahmaputra Board (BB)
- National Disaster Management Authority (NDMA)

State Government

- Water Resources Departments
- State Technical Advisory Committees (STAC)
- Flood Control Boards,
- Irrigation Departments
- Public Works Departments

Figure 4: *Two Tier System of Flood Management in India*

Government of India has implemented two major schemes viz. Flood Management Programme and Flood Forecasting Scheme towards Flood Forcasting, Control and Management[3].

1. Flood Management Programme: The scheme was sanctioned by the Cabinet in November 2007 with Central Assistance of Rs 8,000 crore in XI FYP (2007-2012). Further, a central assistance of 10,000 crore was approved in October 2013 for XII FYP (2012-2017) for undertaking works related to (i) river management, (ii) flood control, (iii) anti – erosion, (iv) drainage development, etc. During the XI and XII plans Rs 4,723.08 crores was released by MoWR, RD&GR upto March 2016.
2. Flood Forecasting: As of June 2008, CWC was operating 878 Hydrological and Hydro-meteorological sites across the country covering 20 river basins for gauge, discharge,

3 Report on Schemes for Flood Control and Flood Forecasting by CAG 2017

sediment and water quality observations. Besides, CWC also operated 175 Flood Forecasting Stations in the country. An outlay of Rs 130 crore in respect of Flood Forecasting Scheme for XI FYP was approved, of which expenditure of ` 103 crore was incurred upto March 2012. The outlay for XII Plan was Rs 281 crore, of which expenditure of Rs 114.09 crore was incurred up to March 2016.

After these the Flood Management and Border Area Programme was launched which is described in detail in next section. The other initiatives of Government of India are given in Annexure IV.

Critical Review of the various Flood Management Works in India

1. In India, we have history of attaching the highest priority to Flood Control Infrastructure (FCI) which includes dams, channels, embankments etc. The importance can be gauged with the fact that Dams are referred as the "Temple of Modern India". However, these big infrastructural projects have their own limitations like:

    a. FCI is designed with a specific capacity and is a centralized solution of large scope. Such nature makes it too rigid to quickly adjust to changing boundary conditions, such as local floodplain urbanization and upstream deforestation, which persistently make the protection level insufficient.

    b. The efficacy of FCI depends heavily on unreliable factors. One example is the long-term commitment of periodic maintenance to counter undesirable river adjustment that compromises FCI's capacity and structural integrity. The cost of maintenance frequently exceeds initial estimate due to unexpected, emergent problems[4]. Dredging, particularly, is often too expensive to be implemented as frequently as needed[5].

    c. FCI produces social injustice by forcing its costs onto other communities[6]. The degradation of local riverine ecosystems attributed to FCI can have little impact on the associated city, since cities typically exploit biological productivity and freshwater elsewhere[7]. However, rural communities upstream and downstream can be impacted if they depend heavily on the river for livelihoods. These communities can also suffer from increased flood risk transferred by FCI. In many cases, rural communities are often sacrificed during extreme basin-wide flood events, strategically flooded to avoid inundation of economically and politically more important cities. It was seen in 2011 in the floods of Mississippi River in the USA, Chao Phraya River in Thailand and 2018 in Kerala Flood in India.

    d. Even if the levee effect does not exist, FCI can still worsen long-term flood risk through structural failure when the capacity of FCI is eventually overwhelmed.

4 Smits AJM, Nienhuis PH, Saeijs HLF (2006) Changing estuaries, changing views. Hydrobiologia 565:339–355

5 Mount JF (1995) California rivers and streams: the conflict between fluvial processes and land use. University of California Press, Berkeley

6 Smith K, Ward R (1998) Floods: physical processes and human impacts. Wiley, New York

7 Folke C, Jansson A, Larsson J, Costanza R (1997) Ecosystem appropriation by cities. Ambio 26:167–172

Levee or dam breach would cause water and sediment to plunge onto the urbanized floodplain at high velocity to leave little or no evacuation time. Once it occurs, other intact levees would complicate drainage and prolong inundation to exacerbate the disaster[8]. Structural failure is less predictable and more damaging than naturally slow-rising floodwater, impacting more people in a single instance[9]

e. FCI's very function—preventing periodic flooding—exerts significant ecological impacts. The idea that ecological impacts and flood safety are tradeoffs has justified the management practice that prioritizes flood control over ecological conservation and restoration. As the socioeconomic value of ecosystem services of urban rivers are increasingly recognized[10], it is questionable whether sacrificing river health for only short-term protection is sensible. In wealthier cities, while the ecological decline associated FCI do not seem to limit urban development, the long-term socioeconomic impacts associated with the ecological decline remains to be seen. In low-income urban communities where the less privileged still depend on the river for fishery and water supply, the ecological impacts should be a serious concern[11]. In both cases, society should recognize that flooding is not merely a hazard but also critical mechanism to maintain socioeconomically valuable ecosystem services[12]

2. Inadequate maintenance of flood protection structures like embankments, groynes, spurs etc. leads to repeated failure of constructed flood protection works.

3. The flood protection works are done more as a fire fighting one instead of based on a flood control master plans for flood prone basins.

4. Non-involvement of beneficiaries in the maintenance of flood protection works which benefit them is major lacunae.

5. As per report on 'Schemes for Flood Control and Flood Forecasting'[13] on July 21, 2017. The audit covered flood management projects, and river management activities, including dams in 17 States and Union Territories from 2007-08 to 2015-16. According to the report, against a target of installing 219 telemetry stations (recording and transmitting readings of the flood forecasting instrument) between 2012 and 2017, only 56 had been installed as of August 2016. 59% of the existing telemetry stations were nonfunctional, resulting in non-availability of real time data for the corresponding periods[14].

8 Colten CE, Sumpter AR (2009) Social memory and resilience in New Orleans. Nat Hazards 48(3):355–364

9 Burton I, Kates RW, White GF (1993) The environment as hazard, 2nd edn. The Guilford Press, New York

10 Grimm NB, Faeth SH, Golubiewski NE, Redman CL, Wu J, Bai X, Briggs JM (2008) Global change and the ecology of cities. Science 319:756–760

11 Tockner K, Bunn SE, Gordon C, Naiman RJ, Quinn GP, Standford JA (2008) Flood plains: critically threatened ecosystems. In: Polunin NVC (ed) Aquatic ecosystems. Cambridge University Press, Cambridge, pp 45–61

12 Postel S, Richter B (2003) Rivers for life: managing water for people and nature. Island Press, Washington,DC

13 CAG Report

14 Report on Schemes for Flood Control and Flood Forecasting by CAG 2017

6. Flood management was not taken up in an integrated manner, i.e., covering the entire river or a tributary or a major segment of it and Detailed Project Reports (DPRs) were not prepared in eight states. Delay in approval of DPRs leads to delays in completion of projects. This in turn results in technical designs becoming irrelevant at the time of actual funding of the project. Also, the complete river morphology not studied before the implementation of the piece-meal approach of the channelization/embankment projects.

7. CAG report also furnished that discrepancies in execution of projects, like irregular award of work, splitting of tenders, and payment at higher rates were noted in border areas projects of Assam, North-Bihar and Eastern Uttar Pradesh. Emergency Action plans for only 7% of states have been prepared. Only two out of the seventeen states have carried out a pre- and post-monsoon inspection of dams.

Solutions: International Case studies for better flood management

1. **Flood Resilience:** Coupling with ever-changing local, basin, and global conditions, rivers will continue to change by interacting human and natural processes to make flood control difficult. It is risky for cities to continue to count on FCI to prevent flood damage. Resilience—the capacity to cope with whatever the future brings—is the best policy to survive in a stochastic world. Flood resilience is not about flood prevention but concerns survival through flooding. Tolerance of flooding is thus important to prevent flood damage in the first place, and it depends on whether the city is adapted to floods. There exist communities that live with floods, functioning normally through periodic flooding and even harnessing the ecological benefits of it. Resilience to a disturbance is cultivated through learning from and adapting to that very same disturbance over time[15].

Yokohama, Japan has used flood control and flood adaptation to prevent flood damage.

2. **Flood Proofing the Buildings:** Some traditional strategies are still kept in the modern concept of flood proofing[16]. Flood proofing involves permanent or emergency techniques to prevent or minimize floodwater damage to the building[17]. Techniques such as building on fills and flood barrier shields simply push floodwater elsewhere. Techniques allowing floodwater to enter the structure without damaging it are more socially responsible. These include building with pilotis or on buoyant foundation (present in Yokohama, Japan); using water-resistant building

Buoyant buildings or "amphibian houses" — which sit on dry land but can float vertically during flooding — have been built in Maasbommel, the Netherlands.

15 From flood control to flood adaptation: A case study on the Lower Green River Valley and the City of Kent in King County, Washington by Kuei-Hsien Liao (https://link.springer.com/article/10.1007/s11069-013-0923-4

16 Parker DJ (2000) Introduction. In: Parker DJ (ed) Floods, v2. Routledge, London, pp 3–5

17 NHRAIC: National Hazards Research and Applications Information Center (1992) Floodplain management in the United States: an assessment report, vol 1. Prepared for Federal Interagency Floodplain Management Task Force

materials and water-tight seals to resist moisture and mold; and flexible uses of the lower floors[18].

3. **Revamping the Modern Infrastructure:** Modern infrastructure is often characterized by rigid structures and operational schemes that they cannot respond quickly to disturbances[19]. One strategy of flood adaptation is to break entire inflexible system into small, simple and flexible pieces which can fit together to form new but advanced system. Take the transportation system for example[20]. Flooding would not disrupt mobility if the transportation system does not depend solely on roadways and vehicles. The transportation system could be "amphibious," incorporating both land-based and waterborne transportation modes that can be easily switched back and forth. Within a community, mobility could be maintained simply by putting up temporarily raised walkways, as is practiced in Venice, Italy. Flood adaptation of infrastructure may not require advanced technology but requires redesigning it at the system level.

In Venice Itlay, along with the water based transportation, temporarily raised walkways are used for mobility and transportation.

4. **Open spaces in Urban Areas:** It is increasingly common to direct excess floodwater/ stormwater to green spaces to prevent buildings and infrastructure from flooding. These sunken grassy areas between buildings also function for temporary stormwater retention. Designed creatively[21], urban open spaces can function for floodwater conveyance and storage while maintaining recreational and esthetic values. These open spaces could be interconnected through surface and underground trenches to become a network to hold a significant amount of floodwater to prevent buildings and infrastructure from flooding. A strategic rearrangement of different types of open spaces could maximize human access. More intensively used spaces such as sports fields, playgrounds, and parking lots can be assigned to higher ground that floods less frequent in the network, while passive recreation can take place at lower ground that floods more often.

12-km Indian Bend Greenbelt in Scottsdale, Arizona, US, and the 324-ha Erchong Flood Spillway Park in Taipei, Taiwan have been set aside to convey floodwater during emergency conditions.

Yonging River Park in Taizhou, China, and the Bishan-Ang Mo Kio Park in Singapore are the urban parks designed as wetlands or floodplains to allow periodic flooding.

18 Zevenbergen C, Cashman A, Evelpidou N, Pasche E, Garvin S, Ashley R (2011) Urban flood management. CRC Press, London

19 Hallegatte S (2009) Strategies to adapt to an uncertain climate change. Glob Environ Chang 19:240–247

20 From flood control to flood adaptation: A case study on the Lower Green River Valley and the City of Kent in King County, Washington by Kuei-Hsien Liao (https://link.springer.com/article/10.1007/s11069-013-0923-4

21 ibid

5. **Flood Plain Restoration:** Floodplain restoration refers to excavating channels and ponds, planting aquatic and terrestrial native vegetation, and placing cobbles, boulders, and large woods to resemble the natural floodplain landscape. Floodplain restoration is carried out in all existing open spaces except in the flood control zone, such that they are either larger wetlands parks or smaller wetland gardens[22]. Processes naturally accompanying flooding, such as spontaneous succession, erosion, sedimentation, and debris deposition, are allowed to occur to periodically rework the landscape. These processes are known to contribute to diverse topography, high species diversity, and intensified ecological processes in natural rivers[23]. The ecologically functioning floodplain and riparian zone could bring a host of ecosystem services to benefit the city directly, such as water purification through trapping sediments and processing diffuse nutrient pollutants brought by floods, storm water runoff, and groundwater from upstream and upland areas[24]. Floodwater stored in the open spaces could restore the process of floodplain aquifer recharge to prevent subsidence. It would also ensure base flows during the dry season to help lessen the climate change impact because summer flows are expected to reduce and it could make fish passage increasingly difficult[25].

Some examples of Flood Plain Restoration are The Rhine Delta, Netherlands and The River Skerne, UK.

Figure 5. *Various approaches to Flood Management*

22 Floodplain Restoration and Storm Water Management: Guidance and Case Study (2009), http://crwp.org/files/floodplain_restoration_sw_management_march_2009.pdf

23 Naiman RJ, De´camps H, McClain ME (2005) Riparia: ecology, conservation, and management of streamside communities. Elsevier Academic Press, New York

24 Pinay G, Clement JC, Naiman RJ (2002) Basic principles and ecological consequences of changing water regimes on nitrogen cycling in fluvial systems. Environ Manag 30(4):481–491

25 Mantua N, Tohver I, Hamlet A (2010) Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. Climate Change 102:187–223

Section 4

Major Flood Events of the Country: Case Studies and Lessons Learnt

Major Flood Events of the Country: Case Studies and Lessons Learnt

Floods as already described in pervious chapters are the most common yet most destructive natural disaster in India. Over the years, the intensity of floods has increased and associated destruction is also on high surge. But every disaster presents an opportunity to redress the situation. It teaches us some lessons which can be used to prepare ourselves for the future disasters. This chapter elucidate the major flood events in India and the key lessons learnt from them. This chapter will help the policy makers to understand the sequence of flood occurrence and post flood best practices adopted by the affected state governments. But before that given below is the summary of some major flood events of last few years.

Table 2: Major Flood Evens of Last few Years

State	Year	Reason	Death	Population Affected	Property Damage
Assam	2012	Heavy Rainfall	20	Over 2 Million	-
Uttarakhand	2013	Monsoon flood	Nearly 4100	Nearly 4000 villages	21141 Houses and estimates of 50000 Cr loss in infrastructure
Madhya Pradesh	2013	Heavy Rainfall	30	40000 people	24000 houses
Jammu	2013	Heavy Rainfall	29	2600 villages	15,712 buildings, houses, agriculture buildings.
Assam	2014	Heavy Rainfall	10	25000 displaced.	-
West Bengal	2015	Cyclone and rainfall	48	10,000 villages in 12 districts	38000 Houses
Assam	2015	Heavy Rainfall	2	700 villages 15 districts 311,000 people	11000 Hectares crop
Tamil Nadu	2015	Heavy Rainfall	500	1.8 million	Rs 50000 Cr
Andhra Pradesh	2016	Long Term Heavy Rain	15	25000 people	50,000 hectares of crops.
Bihar	2016	Long Term Heavy Rain	17	1,500 Villages, 8 districts, 3.753 million.	-
Gujarat	2017	Extreme Rainfall	224	0.3 million	Rs 10 cr

Bihar	2017	Long Term Rainfall	253	180,000 people in 10 districts	25000 buildings
Uttar Pradesh	2017	Long Term Rainfall	10	2,000,000 people	1182 Buildings destroyed
Kerala	2018	Heavy Rainfall	339	5.4 million	75, 857 cattle, 6.42 lakh houses were damaged. In addition, 82 thousand hectares of standing crops
Bihar	2019	Heavy Rainfall	116	10 million	-

Source: Various Ministerial Sources

Uttarakhand Flood 2013

On 16 June 2013, the State of Uttarakhand suffered mega disaster, one of the worst disasters in the living memory, causing widespread damage and destruction, besides heavy casualties. The entire State was hit by very heavy rainfall and flash floods. Though all the thirteen districts of the State were hit, five districts, namely Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttarkashi were the worst affected. The disaster coincided with the peak tourist and pilgrimage season, significantly enhancing the number of the casualties and adversely affecting the rescue and relief operations. The impact of disaster was most pronounced in the Mandakini valley of the Rudraprayag district. Torrential rains, coupled with the probable collapse of the Chorabari Lake, led to flooding at the Kedarnath Shrine and the adjacent areas of Rambara, Agastyamuni, Tilwara, and Guptkashi. Other pilgrimage centers in the region, including Gangotri, Yamunotri and Badrinath, which are visited by thousands of devotees during the summer season, were also affected. People in important locations, such as the Harsil, Roopkund and Hemkund Sahib, were stranded for days together. Over one lakh people were stuck in various regions of the State due to damaged roads, landslides and flash flood-induced debris.

Effects of Flood

The disaster caused heavy loss of precious lives and extensive damage to private properties and public infrastructure. More than nine million people were affected by the flash floods. The five districts namely, Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttarkashi were the worst affected. As far as casualty to human lives is concerned, as informed by the State Government on 09 May 2014, a total of 169 people died and over 4,021 people were reported missing (presumed to be dead). As per estimates, the disaster has cost Uttarakhand Rs 50,000 crore in infrastructural loss. Uttarakhand Jal Vidyut Nigam Limited has suffered loss of Rs 77 crore apart from the Rs 50 crore lost in power generation.

Table 3: Damage of Uttarakhand Flood

S.No	Item	Details
1.	Number of Affected Districts	13
2.	Number of dead and Missing person (presumed dead)	169+4021
3.	Number of houses and cowsheds damaged	20141
4.	Animals lost	11091

Major Findings

1. The disaster essentially occurred due to wide spread heavy rains during the period 14-18 June, which resulted in flash floods in all the major river valleys in the State. Heavy rains triggered major landslide at numerous locations causing severe disruption in surface communications.

2. As per the Indian Meteorological Department (IMD), the rainfall in the State between 15 June and 18 June 2013 was measured at 385.1 mm, against the normal rainfall of 71.3 mm, which was in excess by 440%.

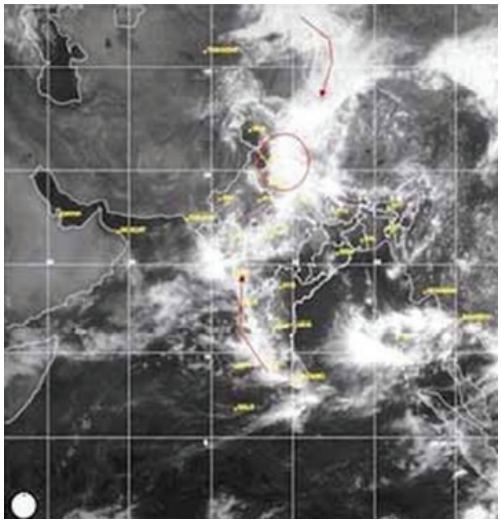


Figure 6: *The Indian Meteorological Department image (17th June 2013) suggested heavy rainfall on the higher reaches of Uttarakhand, Himachal and Nepal Himalaya*

3. Thus, it can be inferred that the disaster was the result of extra precipitation in a very short duration of time, which resulted in heavy water discharge in various rivers and streams.

4. As per the eye witnesses and technical inputs received from various agencies, the possible causes of the disaster could be summarized as:-

   - Collision of western disturbances with monsoon easterlies.
   - Excessive precipitation in very short span of time.
   - Heavy erosion and the accumulation of large volume of water and sediment accumulation in major river beds due to excessive rainfall.

- Run - off of loose debris, moraine and boulders with excessive force washing
- off all that came in its way.

5. The worst impact of the disaster on human settlements was in the Kedarnath shrine area (Gaurikund to Kedarnath), the Mandakini valley, the Alaknanda valley (at Gobindghat and upstream), the Pindar valley, and along the banks of the river Kali in Dharchula area.
6. The Kedarnath area in particular was impacted the most as it suffered unprecedented devastation with very heavy loss of life and property.

Figure 7: *Kedarnath Before and After the Flood*

7. The world's greatest war footing rescue operation was done by all the three wings of army- Army, Air Force and Navy.
8. All the essential supplies like food, drinking water, medicines, kerosene oil, solar lamps, etc. were continuously provided by air dropping as well as by surface means. A total of 69 relief camps were run, where 1,51,629 pilgrims/ local residents were looked after. Some camps continued operating beyond the emergency phase for the local residents. Approximately 900 trucks of relief material were received from other states and dispatched to the affected districts from a nodal/ relief centre, set up at Dehradun.
9. Forty-three medical teams comprising of 313 doctors and 4977 para-medical staff, were deployed and essential medicines, bleaching powder and chlorine were regularly supplied.

Key Takeaways

1. The Uttarakhand flash floods of 16 - 17 June 2013, were one of the worst disasters to strike Uttarakhand. Though the disaster essentially occurred due to natural hazards, the vulnerability to the disaster was enhanced manifold by anthropogenic activities. The disaster revealed several infirmities in our preparedness, which need to be rectified at the earliest. Some of the important lessons learnt and key takeaways are listed below: -

2. Flood Plain Zoning Act regulating construction within the flood plain of a river should be implemented strictly.

3. For clearance of all hydro-power and other mega projects in ecologically sensitive regions like Uttarakhand, the Disaster Impact Assessment (DIA) should also be made compulsory besides Environmental Impact Assessment (EIA).

4. Landslide risk zonation mapping be completed on priority. Development and enforcement of guidelines, regulations and codes for landslides is critical.

5. Effective stabilization of slopes in shear and weak zones be undertaken using scientific techniques available at national/international levels.

6. Blasting for developmental activities be avoided as it may destabilize the weak rocks in mountainous regions.

7. Disaster management plans be regularly reviewed and updated to ensure a functional structure and accountability for all actions initiated by the State Government to enhance preparedness.

8. The existing emergency communication system is reviewed regularly to ensure last mile connectivity during disasters.

9. Investments in infrastructure development related to weather, glacial lakes, river flow monitoring, etc. are fundamental for improving the accuracy of risk mapping, thereby allowing more lead-time for warnings provided by IMD, CWC, GSI, NRSC, etc.

10. Tourism related development should not be allowed along the river banks.

11. An effective pilgrim control and regulatory body should be constituted for control and management of pilgrims/tourists.

12. Stockpiling of essential items like food grains, blankets, medicines, etc. must be ensured at block/panchayat levels in designated areas for an emergency.

13. Supply of essential commodities by animal transport in remote disaster-prone areas should be examined on regular basis and included in relevant disaster management plans.

14. The community-based disaster management system at the local level must be given utmost importance and strengthened through appropriate training and awareness programmes.

15. The mechanism of Incident Response System be established at relevant levels and be dovetailed into the disaster management plans. State and district agencies should build their command and coordination structures to support the local command and coordination structures during an emergency.

16. Need to integrate the contributions of volunteers and non-governmental organizations in disaster response at the State level. This integration would be best achieved at the district and local levels. NGOs should be engaged in the planning process for their involvement in a joint response.

Tamil Nadu Flood 2015

Tamil Nadu recorded an exceptionally heavy rainfall during November - December 2015 due to the North East Monsoons. This unprecedented rainfall took place in four spells:

i. November 8-10, 2015 causing extensive damages, mainly in Cuddalore district;

ii. November 12-13, 2015 severely affecting Kancheepuram town;

iii. November 15-17, 2015 bringing heavy rain to Chennai and the adjoining districts of Kancheepuram and Thiruvallur; and

iv. November 30 to December 07, 2015 which again hit Chennai and the two adjoining districts with such great intensity that it marooned large parts of the metropolis causing severe damage and destruction, and marooning large parts of the metropolis with people stranded on rooftops for days together, especially in the low-lying areas.

While the first three spells of rains caused flooding in many districts of Tamil Nadu, causing damages to infrastructure and property and distress to people, the final spell on 2nd December, 2015, flooded densely populated areas of Chennai Metropolis and adjoining districts of Kancheepuram and Thiruvallur. This unprecedented rainfall in a short duration led to devastating flash floods causing major damages to irrigation infrastructure, roads and public amenities as well as loss of human lives and livestock.

Effects of Flood

It is estimated that around 500 people lost their lives and over 18 lakh (1.8 million) people were displaced. With approximations of damages and losses ranging from ₹50000 crore (US$7 billion) to ₹100000 crore (US$15 billion), the floods were the costliest to have occurred in 2015, and were among the costliest natural disasters of the year.

Figure 8: *Chennai Flood*

Major Findings

1. The outcome of this unprecedented level of downpour was immediate and disastrous with major water bodies getting filled and flowing into major rivers, Adyar, Cooum and Kosathalai, which in turn overflowed into densely populated areas of Chennai City,

transforming Chennai into islands of houses in a vast expanse of water many feet high. This flood put a large number of urban populaces of these areas in great difficulty and caused severe damages to public and private property. Water entered buildings, even in first floors in some areas, stranding residents on building rooftops without essential provisions - food, water and electricity, besides completely damaging all their household durable assets and motor vehicles, and rendering their homes uninhabitable for long period to come. People were shifted to temporary shelters set up by the State Government.

2. The rapid urbanization has attributed a lot in the 2015 floods. As a consequence of urbanization there is reduction in infiltration component of the hydrological cycle, which will increase the peak run off discharge. It has also led to encroachment of waterways which reduces their vent away. For example, construction of new runway of Chennai airport which was flooded during the 2015 rain is built on Adyar River.

3. Chennai during the flood has experienced the "compound wall effect". Compound walls are built around almost all institutions to save them from encroachment. This resulted in alteration of local overland flow paths and some even blocked the local channels. This turn changed the local flooding patterns, protecting some and endangering some areas. In some cases, by blocking the natural flow and cross drainage they contributed in localized flooding.

4. The Chennai city used to have large marsh lands, wetlands and vast tract of pasture land in the south which used to act as the flood sink of the city. But during 2010-11, along with marshlands, all other wetlands of Chennai became sites of waste disposal, housing, commercial and industrial purposes. As city sprawled towards south these marshlands became fragmented which destroyed flood sink of the city and resulted in citywide floods[26].

Key takeaways

1. The Government directed officials to conduct special camps for two weeks to receive applications from the affected public and issue necessary copies of documents within a week without collecting any fee. This order was applicable for the flood-affected people of Chennai, Kancheepuram, Thiruvallur and Cuddalore districts only and was to stay in force till the completion of the special camps for issue of the above said copies/duplicate documents. Subsequently, the issue of duplicate documents was initiated free of cost.

2. Each disaster presents an opportunity to learn from it. The Tamil Nadu Government used the opportunity presented to it after the December 2015 deluge to strengthen disaster preparedness in the State. A year later, in December 2016, the city was face-to-face with another extreme weather event, the tropical Cyclone Vardah. This time around, the government had put in place preparedness measures to deal with any freak rainfall,

26 https://www.slideshare.net/SaranyaNarayanaMoort/chennai-floods-2015-report

flood, cloudburst, drought or cyclonic storm incident well in advance. The actions taken by Government were:

- Special drive to clean channels leading to water tanks is undertaken before the monsoon season.
- Gaps between Government and Private Sector efforts were bridged. Private companies came forward, post-disaster, for repairing vehicles, re-phasing loans and personnel management.
- The State Government had convened a meeting with all Stakeholders to discuss their
- contingency plans which ensured pre-emptive deployment of response forces. Additional
- Teams of NDRF, SDRF and Columns from Army, Navy and Coast Guard were mobilized and pre-positioned in vulnerable areas.
- Similar meetings were held at the district and state level to sensitize hospitals, educational and industrial organizations, communication service providers and Oil Companies etc. sensitizing them to be equipped with institutional strategies for immediate response during disasters. They were also sensitized to make back-up arrangements to ensure continuity of life saving services, especially in the hospitals.
- A coordinated approach covered timely evacuation and minimum casualties.
- Power supplies were turned off during floods/cyclonic storms.
- Diesel Generators (DG) were shifted to elevated level/upper floors. DG sets of mobile service operators were damaged during 2015 floods as they were installed in the basements.
- Sufficient diesel/oil stock with power/oil/telecom companies with proper storage facilities at safe locations. While only BSNL had enough stock during 2015, each of these service providers had enough stock during the 2016 North East Monsoon.
- During the 2016 North East Monsoons, at least 5,000 culverts were cleaned beforehand.
- Similarly, bridges and culvert outlets were also cleaned – 500 metres upstream and an equal distance downstream.
- When schools were re-opened after floods, water storage tanks were cleaned and fi lled with fresh water.
- Power supply to government hospital buildings were restored first. Later, step-by-step restoration of power for other important establishments was done.
- Chlorination of water tanks were done before North East Monsoon season.

- Massive exercises for desilting 22,899 tanks and 11,446 kms of water bodies were taken up. In addition, clearing of blockages on either side of at least 15,870 bridges and more than 1.4 lac culverts for up to 500 upstream and downstream were also undertaken and encroachments were removed.
- A total of 6,960 recharge pits were created and 8,657 defunct bore-wells were also converted as recharge-pits.
- Formation of green corridors in vulnerable areas to facilitate rapid movement of rescue teams to undertake necessary operations.

Kerala Flood 2018

Kerala State has an average annual precipitation of about 3000 mm. The rainfall in the State is controlled by the South-west and North-east monsoons. About 90% of the rainfall occurs during six monsoon months. Kerala experienced an abnormally high rainfall from 1 June 2018 to 19 August 2018. This resulted in severe flooding in 13 out of 14 districts in the State. As per IMD data, Kerala received 2346.6 mm of rainfall from 1 June 2018 to 19 August 2018 in contrast to an expected 1649.5 mm of rainfall. This rainfall was about 42% above the normal. Further, the rainfall over Kerala during June, July and 1st to 19th of August was 15%, 18% and 164% respectively, above normal.

Due to heavy rainfall, the first onset of flooding occurred towards the end of July. A severe spell of rainfall was experienced at several places on the 8th and 9th of August 2018. Water was released from several dams due to heavy rainfall in their catchments. The water levels in several reservoirs were almost near their Full Reservoir Level (FRL) due to continuous rainfall from 1st of June. Another severe spell of rainfall started from the 14th of August and continued till the 19th of August, resulting in disastrous flooding in 13 out of 14 districts.

Table 4: District wise rainfall during 1 June 2018 to 22 August 2018

District	Normal Rainfall (mm)	Actual Rainfall (mm)	Departure from Natural (%)	
Kerala State	1701.4	2394.1	41	Excess
Kasaragode	2609.8	2287.1	12	Normal
Palakkad	1321.7	2285.6	73	Large Excess
Alappuzha	1380.6	1784	29	Excess
Kannur	2333.2	2573.3	10	Normal
Ernakulam	1680.4	2477.8	47	Excess
Idukki	1851.7	3555.5	92	Large Excess
Kollam	1038.9	1579.3	52	Excess
Kottayam	1531.1	2307	51	Excess

Kozhikode	2250.4	2898	29	Excess
Malappuram	1761.9	2637.2	50	Excess
Pathanamthitta	1357.5	1968	45	Excess
Thiruvananthapuram	672.1	966.7	44	Excess
Thrissur	1824.2	2077.6	14	Normal
Wayanad	2281.3	2884.5	26	Excess

Source: *CWC report*

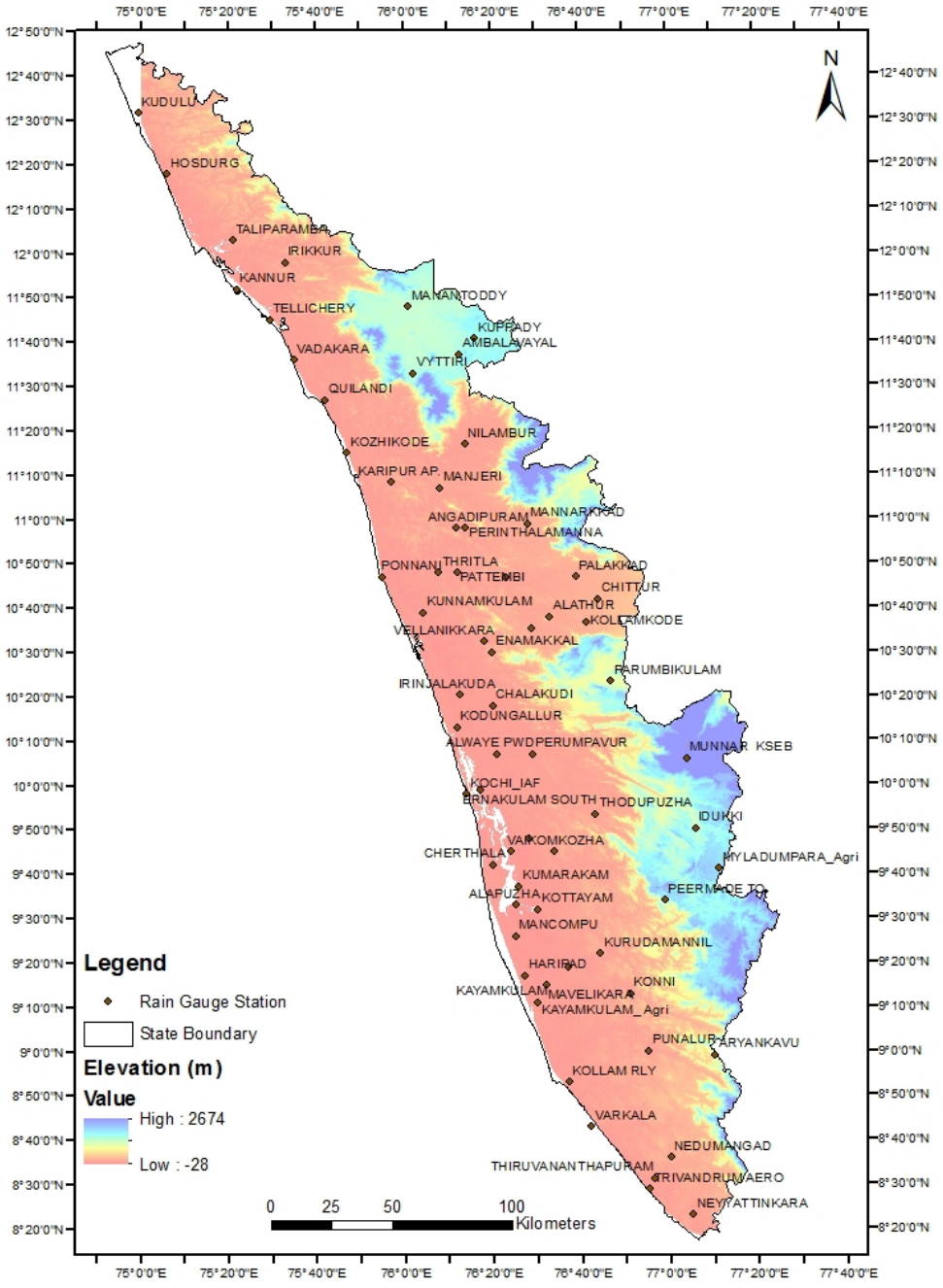


Figure 9: *Rain gauge stations of Kerala used for rainfall analysis*

Effects of Flood

Kerala was very badly affected by the flood and lost nearly 33 were destroyed and about 70 thousand kilometer of road network suffered major damage. Centre government approved the assistance of Rs. 3048.39 crore for the floods. The estimated losses of flood from different agencies is US$ 4.25 billion displacing over 8,00,000 people in the region.

Major Findings

1. From the analysis it has been found that the dams in Kerala neither added to the flood nor helped in reduction of flood, as most of the dams were already at FRL or very close to FRL on 14 August 2018, due to more than normal rainfall in the months of June to July 2018. It may be noted that, had the reservoir been a few feet below FRL, the flooding conditions would have not changed much, as the severe storm 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.

2. Nevertheless, it is essential to review the rule curves of all the reservoirs in Kerala. The rule curves need to be meticulously drawn particularly for the reservoirs having the live storage capacity, of more than 200 MCM in order to create some dynamic flood cushion for moderating the floods of lower return periods particularly in the early period of monsoon.

3. 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. Further, the discharging capacity of 630 cumec of Thottappally spillway was the other major constraint for the disposal of runoff. Considering the lake carrying capacity of about 600 MCM and discharging capacity of 630 cumec of Thottappally spillway and about 1706 cumec present discharging capacity of Thaneermukkom barrage, it can be concluded that out of 1.63 BCM the runoff generated during the 15-17, August 2018 rainfall, only about 0.605 BCM runoff was possible to drain out of the Vembanad lake. The remaining runoff volume of about 1 BCM created the rise of the water level in the lake and nearby areas. This continuous rising of lake water may be one of the reasons of overall change in the river hydrodynamics of Pamba, Manimala, Meenachil and Achenkovil river systems resulting higher water level for a particular discharge in these rivers. Considering the high rainfall during 15-17, August 2018, the absence of appreciable storage reservoirs in the upstream in the above rivers along with the shrinkage of carrying capacity of Vembanad Lake and reduction of the capacity of Thottappally spillway worsened the flooding in the Kuttanad region and the backwaters flows to the low lying areas in the upper reaches of the lake.

4. The worst affected districts noticed were Wayanad (Kabini sub-basin), Idukki (Periyar sub-basin), Ernakulam (Periyar and Chalakudi) sub-basins, Alleppey and Pathanamthitta (both in Pamba sub-basin).

5. In a nutshell, it can be concluded that August 2018 flood in Kerala was due to severe storm occurrences during 8-9, August 2018 and 15-17, August 2018. The storm of 15- 17, August 2018 resulted in heavy flooding in Periyar, Pamba, Chalakudi and Bharatpuzha sub-basins of Kerala. 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.

6. The release from reservoirs had only minor role in flood augmentation as released volume from the reservoirs were almost similar to inflow volumes. In fact, Idukki reservoir absorbed a flood volume of about 60 MCM during 15-17, August 2018. Even, with the 75 percent-filled reservoir conditions, the current flood could have not 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.

Key takeaways

1. It is essential to review the rule curves of all the reservoirs in Kerala. The rule curves need to be formulated for both conservations as well operations during the flood, particularly for the reservoirs having the live storage capacity of more than 200 MCM in order to create some dynamic flood cushion for moderating the floods of lower return periods particularly in the early period of monsoon.

2. For efficient discharge of flood runoff from Vembanad lake, the approach channels to Thottappally spillway and the passage of the Thaneermukkom barrage should be widened taking into consideration the lake hydrology, ecology, saline water intrusion, etc based on scientific and engineering inputs.

3. In basins like Periyar, Pamba and Achenkovil basins, Kerala should explore the possibilities of creating suitable storage reservoirs, wherever feasible, for flood moderation and other multipurpose uses.

4. Loans for recovery of essential household articles lost and damaged during the floods from our Co-operative Banks and commercial banks were channelized through the widely networked Women's self-help group Kudumbashree. The interest payment on these loans was borne by the Government of Kerala.

5. Camps were held to speedily reissue lost certificates.

6. The Government of Kerala has also entrusted the Kerala State IT Mission (KSITM) to set up an ICT Platform comprising of Web based backend and a mobile app-based field survey application to document the flood related damage caused to houses and commercial establishments in affected districts.

Figure 10: *Kerala Flood snapshots*

Bihar Flood 2019

Many areas of Bihar experienced heavy rains on 21st September. Water entered 80% of the houses in the capital Patna. The four rivers near Patna, Son, Ganga, Gandak and Punpun, had risen above the danger mark. The release of 2.75 lakhs cusecs of water from Indrapuri barrage across the Sone river worsened the situation in river Ganga which caused panic among people living in Patna. During the flood, some of worst impacted areas were slums in Patna. The slum areas of Rajendra Nagar area, Ramakrishna Nagar, Kankarbagh, boring road, Nala Road, Gandhi Maidan were among the worst-affected localities in Patna. The Pataliputra Colony and Kurji were also severely water logged. These slums faced severe flooding; causing damages to the houses and remained inhabitable for many days afterwards. The unhygienic living conditions in slums and water accumulation during and after rain, which made the situation worse and slum areas flood almost each year now.

Effects of the Flood

28 districts including the capital city Patna is affected. The names of affected districts are Araria, Kishanganj, Madhubani, East Champaran, Sitamarhi, Sheohar, Supaul, Darbhanga, Muzaffarpur, Saharsa, Katihar, Purnea, West Champaran, Buxar, Bhojpur, Samastipur, Lakhisarai, Begusarai, Khagaria, Bhagalpur, Munger, Patna, Saran, Vaishali, Arwal, Jehanabad, Nalanda and Nawada.

Table 5: Damage due to Flood

S.No	Items	Number
1.	Number of Villages affected	1846
2.	Population affected	119 lakh
3.	Number of People Evacuated	1.25 lakh
4.	People dead	116

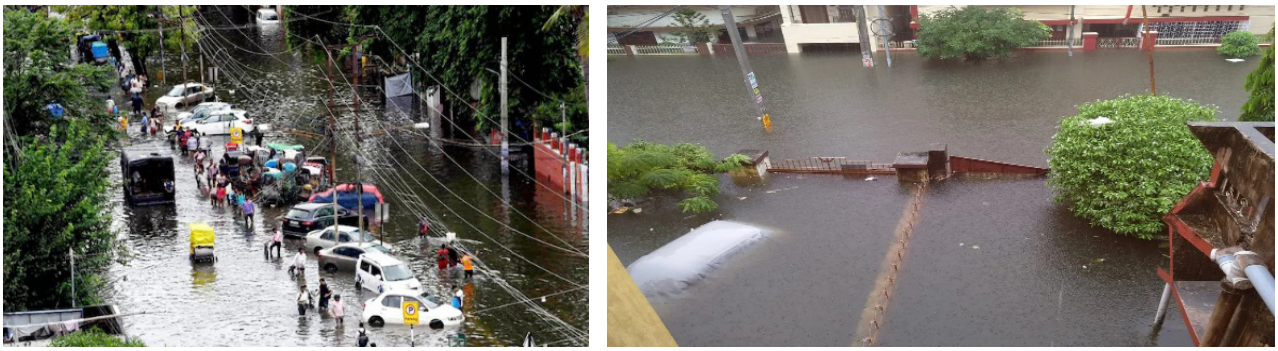


Figure 11: *Patna in 2019 Flood*

Major Findings

1. Flooding in the city appeared to have been caused by a choked, damaged and dysfunctional drainage system, and delayed activation of pumps at the sump houses.
2. As per assessment, there are 40 slums are fully affected by the flood and 16825 families were the victims of flood. In most of the slums water level was 3 feet and 4 slums are not in accessible condition. The water resources are fully contaminated due to the situation, 66.52 % families were denied by safe drinking water too.
3. Flood in Patna impacted the shelter in slums in various ways. The impact ranges from complete collapse of houses to partial damages and minor damages. The slum dwellers need support to help them recover from the impact of flood. In many places, people who lost their homes were unable to return to their home and getting back to normalcy. 3.3% of the houses were completely collapsed and these houses will require reconstruction and major repair work. Shelter support should include options from provision of material and technical support to labour and cash. It is also observed that the families lost their homes were staying at relief camps.
4. As per the analysis the livelihood of both male and female were affected badly by the devastating floods. For female -Domestic works, wage labour, Households chores as domestic maids, Rag pickers, Tailoring labours were affected. For male's construction workers, self-employee, daily wages workers, rickshaw puller, street vendor's labours were affected. It indicates the incapacity of the community members to have proper nutritious food availability in their households.

Key Takeways

1. In order to reduce flood damage in future the effective way is to prevent development in flood prone lands. So the best approach is zoning of such land, however the land use planning as discussed should be adopted so the land contains an outlined use. Zoning can be used to scale back damages from flooding and must be so flexible to acknowledge that different types of land use are compatible.

2. The storm water drainage system is unknown to Patna; what exists in some parts is a sewage network that is meant to double as drainage. At the best of times, this network lies overburdened with unrelieved human effluence. Therefore, there is need for regulated development of the city. Funds to develop the proper sewerage and storm water drainage system in the city can be taken under Smart City Mission, National Mission for clean Ganga and AMRUT.
3. Special drive to clean channels leading to water tanks is undertaken before the monsoon season.
4. All urban water bodies will be protected. Efforts will also be made to restore water bodies by de-silting and taking other measures. Efforts will also be made to revive water bodies that have been put to other uses. Water bodies will be an integral part of the stormwater system.
5. Low-lying areas should be reservedfor parks and other low-impact human activities, Wherever unavoidable, buildings in low lying areas should be constructed on stilts above the High Flood Level (HFL)/ Full Tank Level (FTL),
6. For chronic flooding spots, alternate locations may be explored for accommodating people staying there, Buildings should be constructed on stilts after taking into account the stability of slopes.
7. The nallahs/ drains/ watercourses/ flood plains should be clearly delineated and boundaries fixed in new developments. There will be strict enforcement of the relevant byelaws/regulations in the new layouts.

Hyderabad Flood 2020

On October 14, 2020, after night long rain, the daily rainfall recorded at the weather monitoring station of the India Meteorological Department was 19.2 cm. The water drowned the roads and inundated homes worth crores of rupees in upmarket localities such as Manikonda, Gachibowli, Rajendranagar and Madhapur on the western part of the city.

Effects of Flood

As per the Greater Hyderabad Municipal Corporation data, parts of the Nadeem Colony abutting Shah Hatim Talab had water rise to 12 feet after the downpour on October 13. Devi Nagar and Chudi Bazaar colonies in Goshamahal saw the water rise to 10 feet. Similar were the scenes in several other colonies like Hafiz Baba Nagar, Al Jubail Colony, Ghazi-e-millat colony, Chandrayangutta, Ghouse Nagar, Moin Bagh, Edi Bazaar, Talab Katta and Riyasat Nagar in the old city area. All these localities witnessed water rise to 4 feet. Close to two dozen colonies around LB Nagar too faced a similar fate.

33 lives were lost to heavy rains and floods in the city, with the Greater Hyderabad Municipal Corporation estimating that at least 37,409 families were affected. The Municipal Administration minister pegged the city's losses at Rs 670 crore.

Figure 12: *Hyderabad Flood 2020 Snapshots*

Major Findings

1. Much of the damage was due to the overflowing of lakes — in particular, the Hussain Sagar Lake in the middle of the city and the breaching of storm water drains. Construction over lake beds and encroachments of drainage channels have been identified as problems that have exacerbated flooding and inundation in the city.
2. According to estimates, since last few decades water bodies have drastically come down from 1 lakh to 185 within the greater Hyderabad Capital Region. Out of 185 lakes for 75, the surplus weirs and courses are completely closed. These lakes used to work as flood sink of the city. In absence of these, city is more vulnerable to any natural disaster.
3. Hyderabad and even Telangana state do not have a disaster management plans. They are not fully utilising the doppler radar, which can give advance and precise warnings. The focus is on disaster response, even while allowing unplanned growth.

Key Takeaways

1. Hyderabad urgently needs to expand and remodel its drainage system. Besides lakes and canals, wetlands and watersheds play a vital role in absorbing excess rainfall, but regrettably, rapid urbanization in the twin cities has resulted in the loss of a large portion of the wetlands.
2. An analysis by the Centre for Science and Environment in 2016 revealed that 3,245 hectares of water bodies were lost in Hyderabad between 1989 and 2001. In the long term, the effects of flooding due to deluges can only be mitigated if urban planners take into account the hydro-geology of cities and ensure that construction, development and land occupation do not take place in a way that reduces the area of wetlands.
3. Engineering solutions like linking all the 185 tanks in and around Hyderabad with modern technology to divert flow of water during deluge coupled with measures to

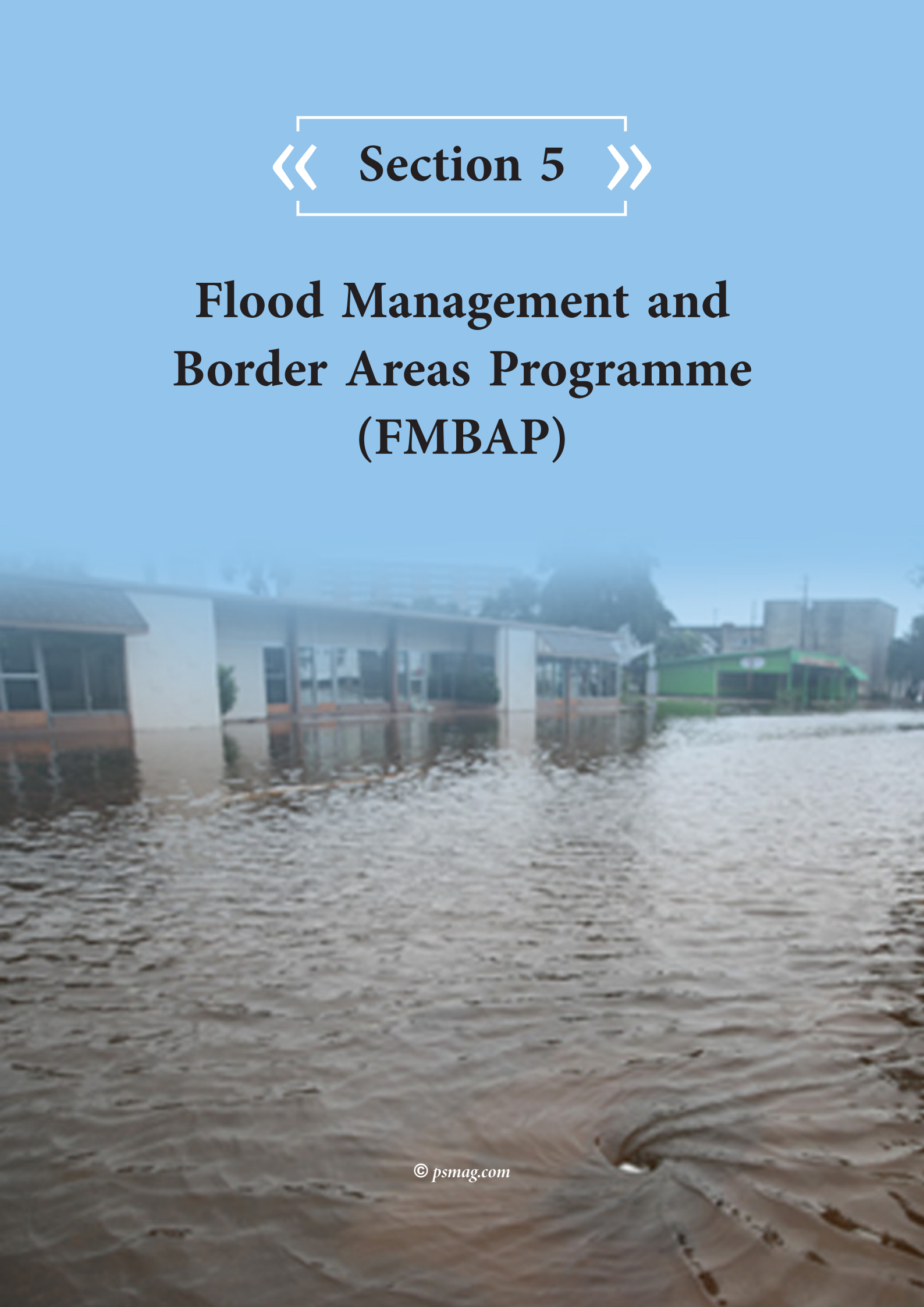
control flood (rainwater) flow by restoring 'nalas' and removing encroachments would help prevent flooding and inundation.

4. The nallahs/ drains/ watercourses/ flood plains should be clearly delineated and boundaries fixed in new developments. There will be strict enforcement of the relevant byelaws/regulations in the new layouts.

5. An underground drainage system should be constructed to flush rainwater from any place, whether it is at a high or low elevation, till the final place of discharge, like the Musi river in Hyderabad's case

Section 5

Flood Management and Border Areas Programme (FMBAP)



Introduction

The projects for flood management and control are formulated and implemented by respective state governments/Union Territories from their own resources and as per their priority. Central Government provides financial assistance to states/UTs for implementing some projects in critical areas. Central Govt. has been providing financial assistance through a scheme called Flood Management Programme (FMP) since XI Plan. The scheme since its inception has undergone several changes as per demands of states/UTs and also on account of various directions and policies of Govt. of India.

Flood Management Programme (FMP)

During X Plan, following four schemes were sanctioned to provide central assistance to the flood prone states to take up flood control and river management works in critical areas:

a. Critical Anti-erosion works in Ganga Basin States (Centrally Sponsored Scheme);

b. Critical Flood Control and Anti Erosion Schemes in Brahmaputra and Barak Valley States (State Sector Scheme);

c. Improvement of Drainage in critical areas in the country (State Sector Scheme); and

d. Critical Anti-erosion Works in Coastal and other than Ganga Basin States (State Sector Scheme).

The Flood Management Programme (FMP) was implemented during XI Plan with an outlay of Rs. 8000 crore after subsuming above four schemes. Under the Programme, central assistance was provided to State Governments for taking up works related to river management, flood control, anti-erosion, drainage development, flood proofing, restoration of damaged flood management works and anti-sea erosion. The pattern of funding was 90 % (Centre):10 % (State) for Special Category States and 75 % (Centre): 25 % (State) for General/ Non-Special Category States. During XI Plan, 420 works with a total estimated cost of Rs.7857.08 crore were approved under FMP. Central assistance to the States/UTs to the tune of Rs. 3566.00 crore was released during this plan period. During XII Plan, the Government of India approved continuation of "Flood Management Programme" with an outlay of Rs.10000 crore. The funding pattern under the Scheme for the special Category States covering the North Eastern States, Sikkim, Himachal Pradesh, Jammu & Kashmir and Uttarakhand was 70% (Centre) : 30% (State) and for General States – 50% (Centre) : 50% (State). The project eligibility criteria for inclusion under the Scheme for special Category States was projects with estimated cost Rs 10 crore and above with Benefit Cost ratio more than 1.0 and for General States it was Rs 40 crore and above with Benefit Cost ratio more than 1.0. The inclusion of projects, inter-se priority of the works etc. was decided through an Inter-Ministerial Committee headed by Secretary (Water Resources), Government of India. During XII Plan (up to 31-03-2017), 102 works with a total estimated cost of Rs.5381.28 crore were approved under FMP. Central assistance to the States/UTs to the tune of Rs. 1307.07 crore was released during this plan period.

River Management Activities And Works Related To Border Areas

During XII Plan, Government of India had approved implementation of the Central Sector Scheme "River Management Activities and Works related to Border Areas" with a total outlay of Rs 740.0 crore to cover the following continuing and new activities.

a. Hydrological observations and flood forecasting on common border rivers with neighbouring countries,
b. Investigations & Pre-construction activities for WR projects on common border rivers,
c. Pancheshwar Development Authority (PDA),
d. Grant in Aid to States/UTs for flood management/anti –sea erosion works,
e. Maintenance of flood protection works of Kosi & Gandak projects (in Nepal),
f. Flood Protection/anti-erosion works in the border areas with Bangladesh and Pakistan by States and Flood Management/anti-erosion works/anti- sea erosion works in UTs,
g. Activities of Ganga Flood Control Commission (GFCC).

The RMBA being specific to activities in border areas with neighboring countries viz. Bangladesh, Nepal, China, Pakistan and Bhutan and for taking up Anti Erosion/Flood Management schemes on rivers on international borders and Union Territories, the projects/ works are funded with 100% central assistance. A Grant-in-Aid of Rs 563.61 (Rs 3401.41-XI Plan & Rs 223.2 Cr XII Plan) were released to various states under this Scheme.

Flood Management and Border Areas Programme (FMBAP)

The Outcome review/Third party evaluation of the two Plan Schemes 'Flood Management Programme (FMP)' and 'River Management Activities & Works related to Border Areas (RMBA)' implemented during XII Plan was carried out by a Committee constituted under the chairmanship of Director, National Institute of Hydrology, Roorkee. The Outcome Review/Third Party Evaluation Committee recommended that only those schemes which are very critical for long-term protection against floods, costing above Rs. 40 crores, may be considered for funding by Union Government under Flood Management Programme. Other schemes / works may be taken up by the concerned State Governments through State Plan allocation. Since the FMP and RMBA schemes have common nature to some extent, the modalities for merging the two schemes in a hybrid/umbrella scheme may be explored and both the schemes may be merged into a single scheme. For the period 2017-18 to 2019-20, a comprehensive scheme titled "Flood Management and Border Areas Programme (FMBAP)" with an outlay of Rs 3342.00 Cr (FMP-Rs 2642 Cr & RMBA-Rs 700 Cr) with merged components from the XII Plan Schemes viz. Flood Management Programme (FMP) and River Management Activities & Works related to Border Areas (RMBA) schemes was approved by the Union Cabinet. The funding pattern for works in general category

states under FMP component remained as 50 % (Centre): 50 % (State) and for projects of 8 North Eastern States, J&K, Himachal Pradesh and Uttarakhand, the funding pattern continued to be 70 % (Centre):30 % (State). Whereas, RMBA component being specific to activities in border areas with neighboring countries viz. Bangladesh, Nepal, China, Pakistan and Bhutan the funding pattern continued as 100% central assistance. During the period 2017-18 to 2019-20 Rs. 1536.95 Crore has been released as Grant-in Aid to the States under FMP component and Rs. 554.16 Crore has been spent under RMBA component of FMBAP thereby making a total of Rs. 2011.91 Crores.

Salient Features Of FMBAP

Some of the salient features of FMBAP Scheme as approved by Union Cabinet for the period 2017-18 to 2019-20 are-

i. FMBAP Scheme is for completion of the spill over works in respect of 83 ongoing projects, already approved under FMP during Xl & Xll Plan as assessed/required and dropping 16 ongoing projects in which the current work progress is less than 50 percent.

ii. The Scheme has a provision only for clearing the committed liabilities of ongoing and completed projects as per extant Xl/ Xll Plan guidelines and that no new project to be included under FM component of FMBAP Scheme till then.

iii. In this Scheme, Administrative Ministry has been authorized to decide inter sub-component and inter-item redistribution of provisions within the overall cost of the respective components of FM (Rs. 2642 crore) and RMBA (Rs. 700 crore) under the Scheme.

iv. The techno-economic Appraisal and Investment Clearance of flood management works under FMBAP continued to be done as per the procedures laid down by Department of Water Resources, River Development & Ganga Rejuvenation.

v. The Inter-Ministerial Committee (IMC) headed by Secretary (WR, RD & GR) with members drawn from Ministry of Finance (Department of Expenditure), Planning Commission (Now NITI Aayog) and other line Ministries / Departments/Organisations constituted during XII Plan to be continued under the scheme for FMP component. For the works under RMBA component, the procedure is proposed to be in accordance with the bilateral mechanism with neighboring countries.

vi. For release of Central assistance to State Government for Projects included under FMP, detailed guidelines of DoWR, RD & GR of October, 2013 describing procedures about submission of documents, budget provisions, Utilisation Certificates, monitoring reports, Concurrent Report, instalments for release of central share to States, etc is followed.

FMBAP Scheme For The Period 2021-26

There has been consistent demand from all the flood prone states that Government of India

should continue to provide financial assistance to flood management projects in the States and new projects should be included for central funding. It is, accordingly, recommended that FMBAP scheme may be continued for the period 2021-26, i.e., co-terminus with the period of 15th Finance Commission with the provision of inclusion of new projects for funding under the scheme. Keeping in view the persistent demand from States to include new schemes under central funding as no new projects have been included for central funding since the year 2015, the proposed outlay of the FMBAP Scheme for period 2021-26 shall be around Rs. 15,000 Crores. Based on suggestions received from the States and issues encountered during course of implementation of existing scheme, following suggestions/modifications are proposed in the new scheme.

a. Threshold Limit for Inclusion:

The current threshold limit for inclusion of new schemes for funding under FMBAP needs to be relooked into. It is proposed that flood schemes which are very critical for long-term protection against floods, costing above Rs. 40 crore with BC ratio more than 1.0, may be considered for funding under Flood Management Programme works in general category States. Whereas, for 8 North Eastern States, J&K, Himachal Pradesh and Uttarakhand, flood schemes which are very critical for long-term protection against floods, costing above Rs. 20 crore with BC ratio more than 1.0, may be considered for funding under FMBAP.

b. Funding Pattern:

There has been demand from Special category states that funding pattern under the Scheme should be 90 % (Centre): 10 % (State) instead of current 70 % (Centre): 30 % (State). It is pertinent to mention that funding pattern of Centrally Sponsored Schemes is guided by the directions of Ministry of Finance. As per the OM of Governing Council Secretariat, NITI Aayog dated 17th August, 2016 the funding pattern for new flood management schemes could be considered as follows (however, it will depend on the provisions applicable at the time of approval of new Scheme)

FMP Component: The funding pattern for works in general category States to be 60 % (Centre): 40 % (State) and for projects of 8 North Eastern States, J&K, Himachal Pradesh and Uttarakhand, to be 90 % (Centre): 10 % (State)

RMBA Component: The RMBA component is specific to activities in border areas with neighboring countries viz. Bangladesh, Nepal, China, Pakistan and Bhutan. The projects/ works continue to be funded as 100% central assistance.

c. Techno-Economic Appraisal of Flood Management Schemes/Projects:

For inclusion of flood management scheme in FMBAP, project reports are required to secure all mandatory clearances from the specified Committees including State Technical Advisory Committee, State Flood Control Board, Forest Clearance, technoeconomic viability acceptance of CWC/GFCC/Advisory Committee of DoWR, RD&GR (as applicable) and investment clearance by the Investment Clearance Committee of DoWR,

RD&GR . The general procedure(s) of techno-economic appraisal has been described in the erstwhile Planning Commission communication No. 16(12)/12003-WR dated 29.06.2012. There have been demands from States for considering enhancement of the existing powers of the State Government for clearance of flood control schemes. A Committee with the approval of Secretary (WR, RD & GR) under the chairmanship of Chairman, CWC was constituted for to review the above existing instructions of Planning Commission, stipulating the procedures and existing powers of the State/UT Government for the sanction of flood control, drainage and anti-water logging schemes. The revision of monetary limits for appraisal of flood control schemes as per the recommendation of Committee as well as the existing powers are mentioned in table below.

Table 6: Revision of monetary limits for appraisal of flood control scheme

S. No.	Appraising Authority	Existing	As proposed by Committee headed by Chairman, CWC
1.	State TAC	< Rs. 12.50 Crores	<Rs. 25 Crores
2.	GFCC (for Ganga Basin) /Regional Offices of CWC (other than Ganga Basin)	> Rs. 12.5 Crore and < Rs. 25 Crores	>Rs. 25 Crores < Rs. 40 Crores
3.	Advisory Committee of DoWR based upon appraisal by GFCC/CWC	>Rs. 25 Crores	> Rs.40 Crores

It is proposed to revise the limits as recommended by the said Committee

d. Monitoring Mechanism of FMBAP Projects:

Extensive and regular Monitoring of the schemes with latest technology using remote sensing tools to be carried out by the Central Water Commission (CWC), Ganga Flood Control Commission (GFCC) and Brahmaputra Board (BB) in their respective jurisdiction. The above central organizations to play an active role at formulation stage of the DPRs for flood management works by the State Governments in their respective jurisdiction and provide necessary guidance in preparation/ submission of the funding proposals in time for appraisal and release of central assistance. The possible use of UAV along with satellite technology to be explored for monitoring of the projects and a comprehensive dashboard to be created for mapping of flood management projects under FMBAP.

e. Utilization Certificate:

As per extant guidelines, for release of installment in any year, the Utilization Certificate (UC) for the full amount of central assistance releases made in previous year is mandatory.

Since second installment is normally released at the far end of previous Financial Year, the proposals for central assistance for a fresh year gets delayed on account of arranging UC of the previous year. In order to streamline this, release of an installment of Central share not to be predicated on producing Utilization Certificates (UCs) of the last instalment and that release to be based on the furnished UC of the penultimate (last to last) release of Central share as per NITI Aayog OM dated 17th August, 2016.

f. Reimbursement of Central Assistance:

In respect of projects included under FMBAP Scheme for central funding, if any, expenditure is made by the State Government towards the Central share from its own resources, the same shall be reimbursable. This is in line with NITI Aayog OM dated 17th August, 2016. However, any expenditure made by the States prior to inclusion of project in FMBAP Scheme shall not be eligible for reimbursement.

g. Installments for release of Central Assistance:

The release of central assistance is done in two installments. In view limited working season for flood management schemes/ anti erosion works which is broadly between 15th November to 31st May, the States Governments particularly from the special category states are demanding that the first installment of eligible central assistance needs to be raised from current level of 50%. Accordingly, it is proposed that the first installment in respect of all States may be kept as 90% of eligible central Share. However, it would be governed by extant guidelines of Ministry of Finance

h. Scope of RMBA Component:

The present scope of RMBA component allows maintenance of flood protection works of Kosi & Gandak projects in Nepal territory only and 100 % Reimbursement is given to the State Governments based upon the recommendation of India-Nepal Kosi High Level Committee (KHLC) and Gandak High Level Standing Committee (GHLSC). Considering the importance and significance of the inundation issues along India-Nepal Border, the current scope of RMBA Scheme may be extended for flood protection works in India on all cross border/border rivers for all neighbouring countries in addition to Kosi and Gandak in Nepal territory as per bilateral agreement. Ministry of External affairs has strongly expressed to include the 100% central funding of river training works on cross border rivers with Nepal due to its international importance. Accordingly, it is proposed that while the existing works/activities shall continue to be part of RMBA component of FMBAP Scheme additional provisions shall be kept for taking up of river training works on all cross border/border Rivers. A comparison of existing and new provisions under RMBA component is at Annexure II.

Section 6

National Water Model for India and preparation Flood Management Plans

Use of Technology

When it comes to disaster mitigation and planning, technology holds a very important role. The latest space technology which includes the use of remote sensing can prove to be an ace for flood control and mitigation. Moreover, use of GIS and Unmanned Arial Vehicles can turn around the whole planning system.

1. **Space Technology:** In order to plan, execute, monitor and maintain the flood management works, it is necessary to acquire timely and reliable information about the flooded areas, watershed areas, river behavior and configurations, etc. prior to floods, during floods, and after floods. Such information is difficult to acquire in time for decision making from conventional ground survey methods, which are strenuous, time consuming and full of limitations, especially while studying floods of large river basins. Satellites due to their remote sensing and data transmission capabilities are the ideal methods to study floods not only in smaller basins but also the large basins. The distinctive ability to provide comprehensive, synoptic and multi-temporal coverage of very large areas at regular interval and at high frequent time periods make them very valuable in mapping, studying monitoring and managing flood dynamics. They can efficiently provide information on i) flooded and congested areas ii) extent of destruction from the flood iii) river configuration iv) status of dams and watershed structures v) collect data from various sources and synthesize them to give a holistic picture of the calamity. They are also useful in delineating the boundaries of flood prone zones and suggesting the appropriate places where structural measures can be adopted to manage flood. Some of the applications of Space Technology are development of early warning systems, monitoring & assessment, preparation of developmental plans for relief, rehabilitation and post-flood assessment. Space technology through Geostationary satellites, meteorological satellites and communication satellites can play an important role in providing valuable information particularly useful in the flood assessment, mitigation and preparedness phases of floods besides weather monitoring and effective communication for early warning and management of the floods.
2. **GIS application in flood management:** A Geographic Information System is a tool that can assist in identifying flood prone areas. The geographical information is stored in a database that can be analyzed by overlaying or intersecting different geographical layers and thus flood prone areas can be identified and targeted for mitigation or stricter floodplain management practices.
3. **Unmanned Aircraft System (UAS):** United States of America for a very longer time is using UAS for flood forecasting, observing dams, detecting levee failures and watershed structures and assessing the damage brought down by flood. Such technology can help to provide timely and secure data.

Development of National Water Model for India

The National Water Model (NWM) is a hydrologic modelling framework developed in USA that simulates observed and forecast streamflow over the entire continental United States (CONUS). The NWM simulates the water cycle with mathematical representations of the different processes and how they fit together. This complex representation of physical processes such as snowmelt and infiltration and movement of water through the soil layers varies significantly with changing elevations, soils, vegetation types and a host of other variables. Additionally, extreme variability in precipitation over short distances and times can cause the response on rivers and streams to change very quickly. Overall, the process is so complex that to simulate it with a mathematical model means that it needs a very high powered computer or super computer in order to run in the time frame needed to support decision makers when flooding is threatened[27].

The NWM runs in four configurations[28]:

- **Analysis and assimilation** provides a snapshot of current hydrologic conditions
- **Short-Range** produces hourly forecasts of streamflow and hydrologic states out to 15 hours
- **Medium-Range** produces 3-hourly forecasts out to 10 days
- **Long-Range** generates 30-day ensemble forecasts.

The NWM improves the National Weather Service's ability to deliver impact-based decision support services nationwide by providing "street level" water information and guidance (e.g., flood maps), as well as serve as the foundation for additional private sector water services.

NWM in India: A similar kind of National Water Model may be attempted in India with the help of some scalable models details of which are given in the graphical format. These models can be used together to feed the information into a decision support system which can provide support services to Nation by predicting and forecasting flood and other water related events

1. **Using Internet of Things (IoT) sensors**

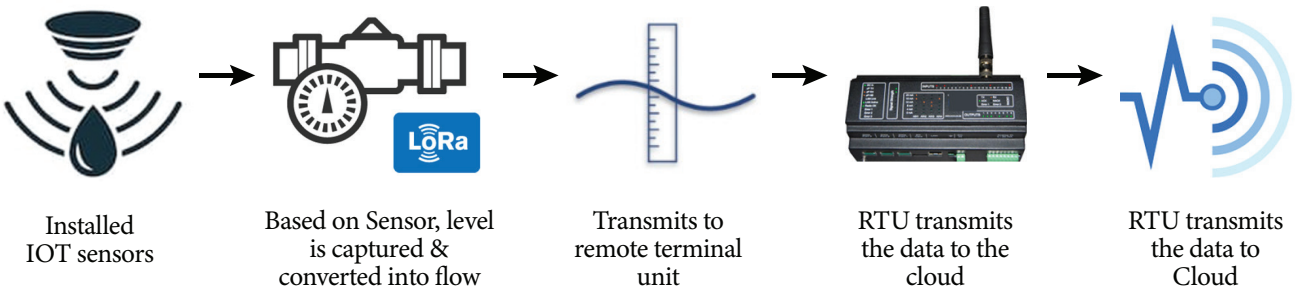


Figure 13: IoT Sensors

27 https://water.noaa.gov/about/nwm

28 https://toolkit.climate.gov/tool/national-water-model

Advantages of the model:

i. Brings near real-time visibility on data;

ii. Records rainfall, Temperature, Levels, Flow ;

iii. Cloud based storage means can be accessed anywhere and safe;

iv. Cloud Computations.

2. Hydrological Model Based Flood Forecasting

The transformation of precipitation into channel flow is a highly complex physical process. A common practice is to use a hydrological model to represent watershed processes. Many different hydrological models have been produced by government agencies, universities, and private companies. They offer a wide range of process simulation options, differing levels of complexity and data requirements, and various degrees of technical support and training. Their application also depends on the forecasting objective, geographical and environmental factors, as well as institutional capabilities. Therefore, the selection of a "best choice" flood forecasting model needs to be based on a systematic approach[29].

Advantages of the model:

i. Leverages historical data and near real-time data for computation

ii. Uses plethora on advanced techniques including GIS

iii. Model requires minimal installation of sensors

3. AI Based Flood Forecasting:

The need for reliable, easy to set up and operate, hydrological forecasting systems is an appealing challenge to researchers working in the area of flood risk management. Currently, advancements in computing technology have provided water engineering with powerful tools in modelling hydrological processes, among them, Artificial Neural Networks (ANN) and genetic algorithms (GA). These have been applied in many case studies with different level of success. These AI and ML based models feed data like rainfall or temporal flow and predict the flow flows at point of Interest.

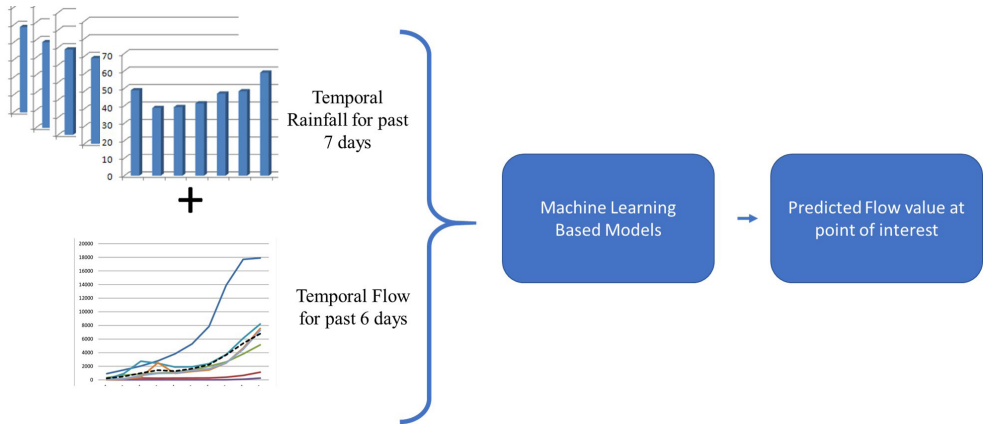


Figure 14: *AI Based Flood Forecasting*

29 http://www.wmo.int/pages/prog/hwrp/documents/FFI/Intercomparison_of_flood_forecasting_models_for_review.pdf

Advantages of the Model

i. Leverages historical data for computation

ii. Model uses the recent Rainfall and corresponding flow to depict reality

iii. Model gives more accurate results over time

Based on the above models, National Water Model can be prepared for the country. The NWM India will be able to do the short term, medium term and long-term flood forecasting. In the event of floods, the alert can be disseminated through SMS or mobile applications. The post flood assessments can be made through satellite imagery or other applications like Drones, UAS etc.

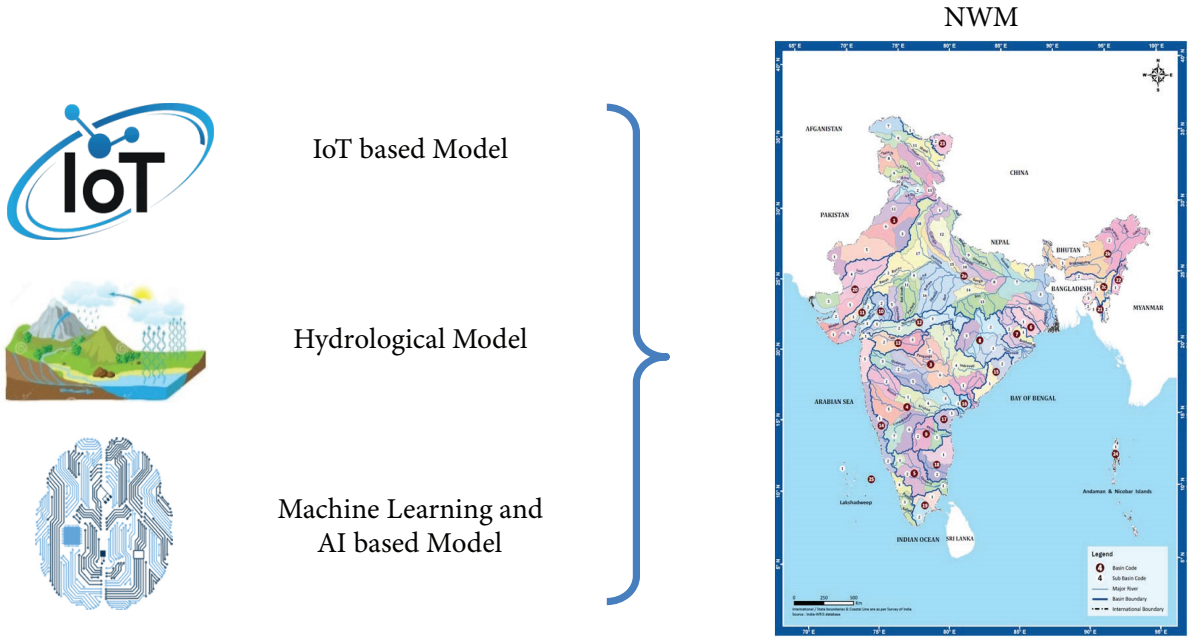


Figure 15: *National Water Model for India*

Flood Management Plans

The most effective way of reducing the risk to people and property is through the production of flood management plans. The flood management plans include all the activities and related preparation in the eventuality of flood. Therefore, it is very important for at-risk communities to develop a comprehensive Floodplain Management plans. A comprehensive plan should include the following activities:

- Identification of flood prone areas: village/block/tehsil or taluka/district wise and delineation thereof on maps.
- Preparation of flood vulnerability/flood risk/ flood hazard maps.
- Putting in place Decision Support System (DSS) for FM including preparedness, rescue, relief, rehabilitation and recovery.
- Developing reliable and country-wide Flood Forecasting and Warning systems in the public domain for all the flood prone areas with sufficient lea time and giving information

on prevailing water levels, area inundated, expected water levels and area likely to be inundated with depth and duration of flooding in a manner easily understood by all.

- Implementation of adequately designed, maintained and sustained structural measures for prevention of flooding and improvement of drainage, leading to feeling of security against floods and overall development in the flood prone areas.
- Operation of reservoirs optimising benefits of flood moderation, irrigation, hydropower, drinking and industrial water supply. Enactment and enforcement of laws for regulating developmental activities in flood plains and prevention of encroachments into flood plains and waterways, thereby reducing flood vulnerability/risk.
- Making the existing and new buildings and infrastructure such as roads, railway lines, bridges, canals, etc. capable of withstanding the fury of the floods and not enhancing flood vulnerability/risk.
- Preparation of states and districts FMPs.
- Training of trainers in professional and technical institutions on FM issues.
- Training of professionals like engineers and architects for incorporating measures that can sustain the structures and provide shelter to people during floods in flood prone areas.
- Implementing demonstration projects on flood-proofing in flood prone areas.
- Launching public awareness campaigns on flood safety and risk reduction and sensitizing all stakeholders to flood problems and mitigation in flood prone areas.
- Undertaking regular inspections of structural works such as embankments, drainage channels, protection works, etc. and implementation of required restoration/strengthening measures prior to and emergency measures during floods in the flood prone areas by the respective agencies/departments.
- Developing an inventory of the existing built environment.
- Assessing the flood risk and vulnerability thereof.
- Developing guidelines for flood-proofing measures and for all existing critical lifeline structures and major public buildings in flood prone areas in a phased manner.
- Preparation of FMPs plans by schools, hospitals, industries, entertainment houses, major shopping complexes etc. in flood prone areas and carrying out mock drills for enhancing preparedness.
- Strengthening the Emergency Operation Centers network.
- Streamlining the mobilization of communities, NGOs, civil society partners, police force, Civil Defence, the corporate sector and other stakeholders on occurrence of floods.

- Preparing community and village level Flood Management Plans (FMPs).
- Creating an inventory of resources for effective response to floods in flood prone areas.
- Strengthening research capability of various academic and research institutions for takingup development of cost-effective Flood Management measures.
- Preparing documentation on lessons from previous floods and their wide dissemination.
- Preparing an action plan for the upgradation and integration/interlinking of the FM capabilities of the CWC, IMD and the state governments in flood forecasting with clear roadmaps and milestones.
- Developing appropriate scheme for insurance of lives, crops and private and public properties in flood prone areas by collaborating with insurance companies and financial institutions.
- Operationalising the NDRF battalions.
- Operationalising the SDRF battalions in the states.
- Allotment for land for the Regional Response Centres.
- Strengthening the medical preparedness for effective response to prevent spread of epidemics especially water-borne diseases after floods.

Section 7

Recommendations

Non-Structural Measures

- Ministry of Jal Shakti to continuously impress upon the States about the need to take action to implement the flood plain zoning approach.
- **(Action: Ministry of Jal Shakti and NITI Aayog -** The ministry along with NITI Aayog ***within next 6 months*** should conduct a workshop with states regarding the problems and situations faced by them while adopting Flood Plain Zoning. Ministry of Jal Shakti may also propose some financial or other incentives for the states implementing the flood plain zoning)
- Continuous efforts to be made towards modernization in collection of hydrometeorological data, flood forecast formulation and forecast dissemination. Further simplified data dissemination policy for use of data by the States particularly regarding trans-boundary rivers to be developed.

  (Action: CWC and NITI Aayog- ***CWC within next 1 year*** should frame a simplified data dissemination policy for use of data by the States particularly regarding trans-boundary rivers and make a presentation to Vice Chairman, NITI Aayog)
- Focus on scientific research in development of Model based system to forecast flash flood with sufficient lead time will provide a much-needed relief from menace of flash floods.

  (**Action: CWC**- *within next 3 years, monitoring agency will be NITI Aayog, time to time presentations on the research will be done to Vice Chairman, NITI Aayog*)
- Rule curve/ level for all reservoirs should be prepared & updated accounting change in rainfall trend and changing demand over the years due to rapid increase of population, urbanisation and industrialisation. Rule curves of major reservoirs, where flood cushion is not in-built, need to be reviewed to have some dynamic flood cushion for major part of the flood season.

  (**Action: State Government, CWC and NITI Aayog:** *State Governments/ Dam owners should prepare the rule curve for all reservoirs within next 1 year and submit it to CWC. Rule curves of major reservoirs, where flood cushion is not in-built, will be reviewed and updated by CWC within next 1 years. The progress regarding to it should be intimated to NITI Aayog on quarterly basis.)*
- Inflow forecasting to be made mandatory for all reservoirs and Emergency Action Plan (EAP) for dam break/extreme flood situations should be ready including flood inundation maps and flood waves & time analysis. Further, SoP for water releases to be made mandatory for all reservoirs. Water release information for downstream areas should be provided with sufficient response time and channel encroachment in downstream stretches of dams to be removed.

(**Action: CWC and State governments**- *Within next 3 years, progress made in these directions will be intimated to NITI Aayog on quarterly basis.*)

- Passing of Dam Safety Bill to be taken up on priority and Integrated Reservoir Operation (IRO) for flood management to be promoted by giving Central Government a proactive role and mandate.

  (**Action: Ministry of Jal Shakti:** *Next session of Parliament*)

- Emphasis to be laid on application of space technology and use of State –of the- art technology in spatial flood early warning and near real-time monitoring and mapping of floods. The National Water Model as proposed in the last sections may be taken up on pilot basis in Koshi and Gandak River Basins.

  (**Action: CWC** - *Within next 3 years, monitoring will be done by NITI Aayog*)

- In order to check the threat of urban flooding, each city should have their flood mitigation plans (floodplain, river basin, surface water, etc.) amalgamated within the overall land use policy and master planning of the city.

  (**Action: Urban Local Bodies, State Governments Ministry of Housing and Urban Affairs, NDMA, Ministry of Jal Shakti and NITI Aayog**- *Urban Local bodies within* ***next 1 year*** *should prepare the Flood Management Plans amalgamating them with overall land use policy and master planning of the cities. MoHUA , NDMA, Ministry of Jal Shakti and state governments should provide hand holding services to ULBs. A workshop may be conducted* ***within 6 months*** *by these agencies along with NITI Aayog to encourage the ULBs to make such plans. The funds for implementation of plans can be sourced from Smart City Mission and AMRUT as major drainage works and city rehabilitation can be covered under these two programmes.*)

- The state governments should strengthen FM education by facilitating the incorporation of the best available technical and non-technical inputs on FM in educational curricula. This effort will address the multi-faceted aspects of FM covering the pre- and post-flood situations that include the inculcation of a culture of prevention, mitigation and preparedness as well as effective and prompt response, relief, rehabilitation and recovery. Case histories of major flood events will be used as valuable inputs in the process.

  (**Action: State Government**- *within next 3 years, monitoring agency will be MHRD which will quarterly send report on the steps taken to NITI Aayog*)

- Specially designed public awareness programmes should be developed by the state governments/SDMAs/DDMAs for addressing the needs of citizens. The people should be made aware of the need to keep special kits containing medicines, torch, identity cards, ration card and non- perishable eatables such as dry fruits, roasted chana etc. ready before commencement of monsoon so that, they can carry the same with them, in case, they have to be evacuated .The community will also be trained for preparation and utilization of improvised flood rescue devices with household articles.

(**Action: State Government, SDMAs, DDMAs**- *Within next 3 years, monitoring agency will be NDMA which will quarterly send report on the steps taken to NITI Aayog*)

- The state governments should proactively support application-oriented research and developmental activities to address contemporary challenges, generate solutions, and develop new techniques to improve their sustainability in floods.

  (**Action: State Governments**- *Within next 3 years; MoJS should conduct a biannual conference to review these researches*)

Structural Measures

- The long-term structural solution to floods lies in construction of large storage reservoirs which moderate flood peaks by adopting appropriate reservoir operation schedule. Government of India has to expedite implementation of storage projects in Nepal as per bilateral agreements. In order to mitigate Brahmaputra flood, flood storage is essential in Subansiri, Siang, Dibang and Lohit sub basins and projects that have been identified in these sub-basins to be taken up for expeditiously. Likewise, to mitigate Barak floods, storage projects in the basin to be taken up.

  (**Action: Ministry of Jal Shakti- Identify** *the storage projects In Nepal; Prepare their feasibility studies; Prepare the DPRs of the identified projects* ***in Next 3 years****; Expedite the constructions of identified projects like Upper Siang, Lower Subansiri and fix a* ***non-extendable timeline*** *for the initiation of their proper functioning; Identify the storage projects in Barak Basin and prepare their feasibility studies* ***in next 3 years.*** *Ministry of Jal Shakti will present the quarterly progress regarding these matters to Vice Chairman, NITI Aayog*)

- To get benefit of flood control, it is essential that tendencies like encroachment of natural detention basins are curbed and these basins are restored to their natural state as a measure for flood control.

  (**Action: State Governments, Ministry of Jal Shakti and NITI Aayog** - *State Governments* ***in next 1 year*** *should prepare a district wise list of natural detention basis, a status note on the level of encroachment and submit the action plan for the restoration of natural state of these detention basins to Ministry of Jal Shakti and NITI Aayog. Ministry of Jal Shakti and NITI Aayog will be the monitoring agencies for the implementation of state- wise action plans. The funds for these works can be sourced from Watershed Component of PMKSY, MGNREGA and proposed FMBAP scheme. The action plan should be implemented by the states in* ***next 3 years***)

- The raising and strengthening of existing embankments, new embankments, channelisation, drainage & channel improvement, anti-erosion works, to be taken up as a flood control and erosion management measures as per requirement of the flood prone States

(**Action: State Governments and CWC-** *State Governments should provide the list of proposed projects along with their techno-feasibility studies to CWC in* ***next 1 year****. The funds for these projects can be sourced from the proposed FMBAP scheme. The appraisal of the project will be according to the revised guidelines suggested in the report. Monitoring of the projects will be on the lines of guidelines provides for the monitoring of FMBAP projects in the report*)

- The projects for interlinking of rivers for diversion of flood water to water scarce areas may be taken up in a time bound manner.

  (**Action: NWDA and NITI Aayog-** *The DPR of Ken-Betwa, Damanganga-Pinjal and Par-Tapi-Narmada link projects have been completed and these projects are in an advanced stage of implementation. NWDA should expedite the implementation of these projects and push forward the DPR formation of rest of identified links. The quarterly presentations on the progress can be made to Vice Chairman, NITI Aayog.*)

- Watershed management works in the hilly catchments of the rivers originating in Nepal, Bhutan as well as in hilly areas of India should be selectively chosen and implemented with central assistance. Effort may be made to treat the hilly catchments to reduce/ minimize the sediment yield from such areas. The steep sloped rivulets/streams in hilly region may be re-graded/ longitudinal slopes reduced to control the velocities of flow by adopting various river training measures. Such measures will arrest the sediment at source or near the source. This will further stabilize the hill slopes adjacent to the rivers. Adopting such methods will further improve the ground water recharge and release such water over extended period of time back to the river system. This will in a way attenuate the peak of the hydrograph, reduce the flooding and ill effects of sedimentation in downstream areas. Nodal Ministry viz. Ministry of Rural Development – Department of Land Resources for the watershed management works may work out a detailed programme in consultation with Ministry of Jal Shakti, NITI Aayog other stake holders of State Government.

  (**Action: Department of Land Resources-** *A detailed programme in consultation with Ministry of Jal Shakti, NITI Aayog, other stake holders of State Government should be prepared within next* ***1 year***)

- The reclamation of the existing wetlands/ natural depressions should be prohibited by state governments and they should formulate an action plan for using them for flood moderation.

  (**Action: State Governments and Department of Land Resources, NITI Aayog**- *A district wise action plan for conservation of wetlands, lakes and natural depressions should be prepared by states and submitted to Department of Land Resources, Ministry of Jal Shakti and NITI Aayog within* ***next 1 year****. Department of Land Resources and NITI Aayog will be the monitoring agencies for the implementation of the action plans which should be get over by* ***next 3 years***)

- Conventional anti erosion works along with cost effective methods like riparian vegetation which interacts with a range of geomorphological, geotechnical, hydrological and hydraulic factors to affect the type and extent of riverbank erosion to be taken.

  (**Action: Ministry of Jal Shakti, MoEFCC, Ministry of Agriculture, DoLR, and State Governments**- *Ministry of Jal Shakti along with MoEFCC, Ministry of Agriculture, DoLR within* ***next 1 year*** *should issue an detailed advisory about the anti-erosion works and cost effective methods like riparian vegetation to the states considering all the geomorphological, geotechnical, hydrological and hydraulic factors. The presentation on the advisory should be made to Vice Chairman, NITI Aayog at the end of 1 year. State governments should move forward to adopt the advisory in the pace suitable to their natural circumstances. Minsitry of Jal Shakti will hand hold and monitor the states in the adoption of advisory*)

- The activities related to control of coastal erosion in an integrated manner to provide environmentally and economically acceptable coastal protection system need to be promoted.

  (**Action: Coastal Protection and Development Advisory Committee (CPDAC), Ministry of Jal Shakti and NITI Aayog**- CPDAC *will form and submit the action plan within* ***next 1 year*** *to control coastal erosion in different ranges of coastal areas to Ministry of Jal Shakti and NITI Aayog. Ministry of Jal Shakti will further facilitate the implementation of action plan* ***within 3 years****)*

- Emphasis to be laid on Integrated flood management which calls for a paradigm shift from the traditional, fragmented and localized approach and encourages the use of the resources of a river basin as a whole and setting up of River Basin Organization for its effective implementation.

  (**Action: Ministry of Jal Shakti**- *Facilitate the passing the River Basin Organization Bill in Parliament in next session*)

- Emergency Action Plan for all big dams should be prepared and implemented when needed.

  (**Action: Dam owners & CWC**- *The dam owners* ***within next 1 year*** *should prepare the Emergency Action Plan and submit it to CWC. CWC as the monitoring agency should ensure the preparation of EAPs*)

Flood Management and Border Areas Programme (FMBAP)

(Action: Ministry of Jal Shakti: *Prepare the cabinet note of the proposed FMBAP scheme within next 3 months including all the changes in the FMP and RMBA guidelines and all the other proposed suggestions***)**

- FMBAP scheme to be continued for the period 2021-26, i.e., co-terminus with the period of 15th Finance Commission with the provision of inclusion of new projects for funding under the scheme. The selection of the schemes will be undertaken in consultation with NITI Aayog and State Government.

- The proposed outlay of the FMBAP Scheme for period 2021-26 to be kept around Rs.15,000 Crores, with Rs.13,000 Crores for FMP component and Rs. 2,000 Crores for RMBA component.
- The funding pattern recommended for schemes in FMBAP is

  FMP Component: The funding pattern for works in general category States to be 60 % (Centre): 40 % (State) and for projects of 8 North Eastern States, J&K, Himachal Pradesh and Uttarakhand, to be 90 % (Centre): 10 % (State)

  RMBA Component: The RMBA component is specific to activities in border areas with neighboring countries viz. Bangladesh, Nepal, China, Pakistan, Myanmar and Bhutan. The projects/ works continue to be funded as 100% central assistance.
- Threshold Limit for Inclusion to be kept as Rs. 40 crore for projects with BC ratio more than 1.0 for funding under Flood Management Programme works in general category States. Whereas, for projects in 8 North Eastern States, J&K, Himachal Pradesh and Uttarakhand, costing above Rs. 20 crore with BC ratio more than 1.0.
- For techno-economic appraisal, the monetary limits of projects of flood control may be modified as recommended by Committee headed by Chairman, CWC, and Adviser (WR), NITI Aayog, Commissioner Flood Management, Ministry of Jal Shakti, Chairman Brahmaputra Board and Chairman, GFCC as members.

Table 7: Revision of monetary limits for appraisal of flood control scheme

S. No.	Appraising Authority	Existing	As proposed by Committee headed by Chairman, CWC
1.	State TAC	< Rs. 12.50 Crores	<Rs. 25 Crores
2.	GFCC (for Ganga Basin) /Regional Offices of CWC (other than Ganga Basin)	> Rs. 12.5 Crore and < Rs. 25 Crores	>Rs. 25 Crores < Rs. 40 Crores
3.	Advisory Committee of DoWR based upon appraisal by GFCC/CWC	>Rs. 25 Crores	> Rs.40 Crores

- Monitoring of FMBAP projects with latest technology using remote sensing tools to be carried out by the Central Water Commission (CWC), Ganga Flood Control Commission (GFCC) and Brahmaputra Board (BB) in their respective jurisdiction.
- The provision of concurrent evaluation by third party is proposed to be dispensed with and performance evaluation of projects after completion may be undertaken by independent agencies like recognized/reputed engineering colleges, research institutions, technical universities, etc. after the works implemented in the scheme withstood at least one flood season after their completion.

- Release of an installment of Central share not to be predicated on producing Utilisation Certificates (UCs) of the last installment and that release to be based on the furnished UC of the penultimate (last to last) release of Central share as per NITI Aayog OM dated 17th August, 2016.
- In respect of projects included under FMBAP Scheme for central funding, if any, expenditure is made by the State Government towards the Central share from its own resources, the same shall be reimbursable. This is in line with NITI Aayog OM dated 17th August, 2016. However, any expenditure made by the States prior to inclusion of project in FMBAP Scheme shall not be eligible for reimbursement.
- The first installment for release of central assistance in respect of all States may be kept as 90% of eligible central Share. However, it would be governed by extant guidelines of Ministry of Finance
- Scope of RMBA Component to be modified for taking up of river training works on all cross border/border Rivers. A comparison of existing and new provisions under RMBA component is at Annexure III.
- Research & Development and Capacity Building on areas of flood management is proposed to be kept as an integral part of the FMBAP Scheme. The research studies for morphological behavior of rivers, sediment carrying capacity of streams, impact of structural interventions and its impact on overall flood management of river basin to be carried out in association with esteemed institutes of the country like IITs, IISc, NITs, etc. Thrust on developing basin flood management plan using State-of-the-art technology and adopting holistic approach at basin level for flood management may be taken as foremost consideration in capacity building under FMBAP.
- The States to be incentivized for adopting Integrated Flood Management approach and taking measures like Decision Support System for integrated operation of reservoirs, flood plain zoning and developing flood management infrastructure in consonance with master plan.

ANNEXURES

Annexures 1

Official Order for Committee Formation

No. 22(155/2016-WR
NITI Aayog
(WR & LR Division)

Sansad Marg, New Delhi
Dated: 29.10.2019

OFFICE MEMORANDUM

Subject: Constitution of the Committee for formulation of strategy for Flood Management Works in entire country and River Management Activities and works related to Border Areas (2020 – 23) - regarding

Consequent upon examination of the draft Cabinet Note on '*Flood Management and Border Areas Programme (FMBAP)*' for flood management works in entire country and river management activities and works in the border areas during 2017-18 to 2019-20 circulated by the then Ministry of Water Resources, RD & GR, the PMO had conveyed that the strategy for flood management for the next three years should be firmed up by a group led by NITI Aayog. The strategy should have clear priorities, costs and deliverables for the next three years (2020-23).

In order to formulate the '*Strategy for Flood Management Works in entire country and River Management Activities and works in the Border Areas for 2020-2023*' a Committee of the following members has been constituted by the competent authority:

1.	Vice-Chairman, NITI Aayog	**Chairman**
2.	Member, Water and Agriculture, NITI Aayog	Member
3.	CEO, NITI Aayog	Member
4.	Secretary, Department of Water Resources, RD & GR, Ministry of Jal Shakti	Member
5	Secretary, Department of Space	Member
6.	Secretary (Border Area Management), Ministry of Home Affairs or his representative not below the rank of Joint Secretary	Member
7.	Joint Secretary, Ministry of External Affairs	Member
8.	Member Secretary, National Disaster Management Authority	Member
9.	Commissioner, Flood Management Programme, Department of Water Resources, RD & GR, Ministry of Jal Shakti	Member
10.	Member (River Management), Central Water Commission, Sewa Bhavan, Sector 1, RK Puram, New Delhi	Members
11.	Principal Secretaries (Irrigation) of Governments of Jammu &	Members

	Kashmir, Uttar Pradesh, Bihar, West Bengal, Punjab, Assam, Arunachal Pradesh, Tripura, Madhya Pradesh and Kerala	
12.	Director, Central Water and Power Research Station, Pune	Member
13.	Prof. Deepak Khare, Water Resources Planning and Management, IIT-Roorkee	Member
14.	Dr. Sharad K. Jain, Director, National Institute of Hydrology, Roorkee	Member
15.	Dr. (Prof.) Biswa Bhattacharya, Hydro-informatics, IHE Delft Institute for Water Education, Delft, The Netherlands	Member
16.	Adviser, Water Resources, NITI Aayog	**Member Secretary**

The Terms of Reference and the Mode of Operation of the Committee are enclosed herewith as **Annexure I and Annexure II**.

The final Report may be submitted by the Committee to the PMO latest by 31st March, 2020.

(Avinash Mishra)
Adviser (WR & LR)
NITI Aayog

To,

1. Sh. U.P. Singh, Secretary, Department of Water Resources, RD & GR, Ministry of Jal Shakti, Shram Shakti Bhavan, Rafi Marg, New Delhi - 110001
2. Dr. K. Sivan, Secretary, Department of Space, Antariksh Bhavan, New BEL Road, Bengaluru - 560 231
3. Secretary (Border Area Management), Ministry of Home Affairs, North Block, New Delhi - 110001
4. Sh. Piyush Srivastava, Joint Secretary (North), Ministry of External Affairs, South Block, New Delhi - 110001
5. Sh. G.V.V. Sarma, Member Secretary, National Disaster Management Authority, Safdarjung Enclave, NDMA Bhawan, A-1, Block A 1, Nauroji Nagar, New Delhi - 110029
6. Sh. J. Chandrashekhar Iyer, Commissioner, Flood Management Programme, Department of Water Resources, RD & GR, Ministry of Jal Shakti

Annexure II

Official order for Sub Committee for Formulation of Strategy for Flood Management Works in entire country and River Management Activities and Works related to Border Areas (2020-23)

No. Z-15012/1/2020-FM/1531-1535
Government of India
Ministry of Jal Shakti
Department of Water Resources, River Development
and Ganga Rejuvenation
(Flood Management Wing)

11th Block, 8th Floor, CGO Complex,
Lodhi Road, New Delhi-110003.

Dated: 4th June, 2020.

OFFICE MEMORANDUM

Subject : Constitution of Sub Committees for "Formulation of Strategy for Flood Management Works in the entire country and River Management Activities and Works related to Border Areas (2020-23)"

In pursuance of decision taken in the second meeting of NITI Aayog on above mentioned subject, a Sub-Committee with following composition is hereby constituted with the approval of Secretary, DoWR, RD & GR

Composition of Sub- Committee

S.No.	Designation	Status
1.	Secretary, DoWR, RD & GR	**Chairman**
2.	Chairman, Central Water Commission	Member
3.	Member (RM), CWC	Member
4.	Chairman, Ganga Flood Control Commission	Member
5.	Chairman, Brahmaputra Board	Member
6.	Secretary, Water Resource Department, Government of Bihar	Member
7.	Principal Secretary, Irrigation and Water Resource Department, Government of Uttar Pradesh	Member
8.	Principal Secretary, Water Resource Department, Government of Assam	Member
9.	Adviser, NITI Aayog	Member
10.	Member Secretary, NDMA	Member
11.	Director, NRSC	Member
12.	Commissioner (FM), DoWR, RD & GR	Member Secretary

The above Sub-Committee will assist the main Committee in formulation of strategy/proposals in the following three focus areas of flood management.

1. Structural Measures of Flood Management

Framing of new guidelines, procedure of appraisal and inclusion of flood management schemes, prioritization of projects for funding both under existing RMBA and FMP component of FMBAP Scheme during 2020-2023, funding pattern of projects, monitoring mechanism, applicability of space technology & modern tools, budgetary provisions and outlay of scheme.

[Action: CWC/FM Wing/GFCC/State Governments]

P.T.O

4/6/2020

Annexure III

Comparison of the existing guidelines with the revised guidelines and reasons for the change in guidelines under the River Management Activities in Border Area Programme (RMBA)

S. No	Existing Guidelines	Proposed Guidelines	Reason for revision
Scope	Maintenance of flood protection works of Kosi & Gandak projects (in Nepal)	Maintenance of flood protection works of Kosi & Gandak projects (in Nepal) and river training works on all cross border/border rivers within Indian territory	Maintenance of flood protection works of Kosi & Gandak projects (in Nepal) would continue as per bilateral agreement River training works on all cross border/border rivers within Indian territory is an important as Issue of inundation along India Nepal Border is a recurring issue and is often raised in bilateral forums.
Procedure for inclusion in RMBA	Maintenance of flood protection works of Kosi & Gandak projects (in Nepal) is recommended by KHLC & GHLSC River training works on all cross border/border rivers within Indian territory.	SameRecommended by JCIFM (for Nepal) / other existing bilateral mechanism after technical appraisal of river training works from GFCC/CWC.	Procedure for inclusion of works in RMBA other than Kosi and Gandak project (in Nepal) needs to be elaborated.
	100 % Reimbursement only for Maintenance of flood protection works of Kosi & Gandak projects (in Nepal) as recommended by KHLC & GHLSC	100 % Reimbursement for all works in border area under RMBA	100 % Reimbursement for all works in border areas under RMBA as these works are of strategic importance.

works to be carried out in No Man's Land in border area	No mention	As per recommendation of MEA	The embankment build along the cross border rivers on both sides by neighboring countries needs tying of embankment in No Man's land area.
Procedure for release of Central Assistance, documentation for flood management works	Not explicitly mentioned	As per detail guidelines of FMBAP	There were different set of guidelines for FMP and RMBA component of FMBAP even after the merger of Scheme as FMBAP. A modified comprehensive guideline on FMBAP would describe procedure and documentation for release of Central Assistance

Annexure IV

Important Government Initiatives and Policies on Floods

S. no.	Year	Initiative	Major Recommendations
1.	1954	Policy Statement	Following the unprecedented floods of 1954, the Union Minister for Planning, Irrigation and Power, placed before the Parliament on 3rd September, 1954, two statements namely "Floods in India - Problems and remedies" and "The Floods in the country". The objective unequivocally set, in the policy statements, was to rid the country from the menace of floods by containing and managing floods and thus solving the problem.
2.	1957	High Level Committee On Floods	i) Absolute or permanent immunity from flood damage is not physically attainable by known methods of flood control. Flood plain zoning, flood forecasting and warning, and like measures should, therefore, be given due importance, particularly as these do not require large capital investment. (ii) Flood control schemes should fit in with other water related plans to the extent feasible. (iii) Future multi-purpose project should consider flood control aspects simultaneously.
3.	1980	National Flood Commission (Rashtriya Barh Ayog)	- Data collection for providing information on their long term performance and their impact on various socio-economic factors. - Legislation and enforcement by States to prevent unauthorized river bed cultivation and encroachments into drains etc. - Separate reporting of flood damage for (i) Unprotected areas (ii) Protected areas and (iii) Areas situated between the embankments. - Legislation for management of flood plains. - Intensifying studies on sedimentation of reservoirs. - Forming a national council for mitigating disaster. - Priority for measures to modify the susceptibility of life and property to flood damage.

4.	2003	Expert Committee to Review the Implementation of the Recommenda-tions of National Flood Commission	- Flood damage assessment, from year to year, is not done realistically or on scientific basis as per RBA recommendations, due to collateral reasons, which are surmised but not expressed. This needs corrective steps. - Lack of representative, scientific and credible post-project performance evaluations of past flood management works is a serious handicap. - Unabated and unplanned intrusion into the flood plains and river beds, sometimes with the approval or acquiescence of Government has now reached alarming dimensions. If this is not managed, flood losses will continue to mount. - The international dimensions of flood management as an integral part of Water resource development and management must be pro actively addressed.
5.	1987/ 2002/ 2012	National Water Policy	(i) There should be a master plan for flood control and management for each flood prone basin. (ii) Adequate flood cushion should be provided in water storage projects, wherever feasible, to facilitate better flood management. In highly flood prone areas, flood control should be given overriding consideration in reservoir regulations policy even at the cost of sacrificing some irrigation or power benefits. (iii) While physical flood protection works like embankments and dykes will continue to be necessary, increased emphasis should be laid on non-structural measures such as flood forecasting and warning, flood plain zoning and flood proofing for the minimization of losses and to reduce the recurring expenditure on flood relief. (iv) There should be strict regulation of settlements and economic activity in the flood plain zones along with flood proofing, to minimize the loss of life and property on account of floods. (v) The flood forecasting activities should be modernized, value added and extended to other uncovered areas. Inflow forecasting to reservoirs should be instituted for their effective regulation.

Annexure V

List of Large Dams having the Emergency Action Plans

S. No.	Agency	Name of Dam
1	Madhya Pradesh Water Resources Deaprtment (MPWRD)	Ari Dam
2	MPWRD	Arniya Bahadurpur
3	MPWRD	Barna
4	MPWRD	Bundala
5	MPWRD	Chandpatha
6	MPWRD	Chandrakeshar
7	MPWRD	Dholawad Tank (Ratlam)
8	MPWRD	Dudhi (Kunwar Chain Sagar)
9	MPWRD	Jirbhar
10	MPWRD	Kanhargaon Tank (Chhindwara)
11	MPWRD	Kankerkheda
12	MPWRD	Kharadi
13	MPWRD	Kolar
14	MPWRD	Makroda
15	MPWRD	Marhi
16	MPWRD	Moorum Nalla
17	MPWRD	Nahlesara
18	MPWRD	Ruthai (Gopi Krishna Sagar)
19	MPWRD	Sampna
20	MPWRD	Sanjay Sagar
21	MPWRD	Sarathi
22	MPWRD	Thanwer (Rajivsagar)
23	MPWRD	Umrar
24	MPWRD	Upper Wain Ganga (Sanjay Sarover)
25	Odisha Water Resources Department (OWRD)	Ashok Nalla
26	OWRD	Banksal
27	OWRD	Bhaskel
28	OWRD	Daha
29	OWRD	Damsal

30	OWRD	Derjang
31	OWRD	Dhanei
32	OWRD	Hirakud
33	OWRD	Jhumuka
34	OWRD	Kalo
35	OWRD	Nesa
36	OWRD	Pillasalki
37	OWRD	Pitamahal
38	OWRD	Salia
39	OWRD	Sapua
40	OWRD	Sarafgarh
41	OWRD	Satiguda (Malkangiri)
42	OWRD	Satiguda (Ukp)
43	OWRD	Sundar
44	OWRD	Talsara
45	Tamil Nadu Water Resources Department (TNWRD)	Aliyar
46	TNWRD	Amaravathi
47	TNWRD	Bhavanisagar
48	TNWRD	Kelavarapalli
49	TNWRD	Krishnagiri
50	TNWRD	Ponnaniyar
51	TNWRD	Sholayar
52	TNWRD	Shoolagirichinnar
53	TNWRD	Thirumurthi Dam
54	TNWRD	Upper (Tirpur)
55	TNWRD	Chinnar Dam
56	TNWRD	Palar Porundar Dam
57	Tamil Nadu Generation and Distribution Corporation (TANGEDCO)	Avalanche
58	TANGEDCO	Bunghihallabund
59	TANGEDCO	Emerald
60	TANGEDCO	Kadambarai
61	TANGEDCO	Kodayar I
62	TANGEDCO	Kundahpalam
63	TANGEDCO	Kuttiyar

64	TANGEDCO	Manalar
65	TANGEDCO	Pegumbahallah Forebay
66	TANGEDCO	Porthimund
67	TANGEDCO	Upper Aliyar
68	TANGEDCO	Upper Bhavani
69	TANGEDCO	Vandal Weir
70	Kerala Water Resources Department (KWRD)	Chimoni
71	KWRD	Chulliar (Gayathri Stage Ii)
72	KWRD	Kanjira Puzha
73	KWRD	Kuttiyadi (Irrign. Proj.)
74	KWRD	Malampuzha
75	KWRD	Malankara / Muvattupuzha
76	KWRD	Meenkara (Gayathri Stage I)
77	KWRD	Neyyar
78	KWRD	Pazhassi Irrigation Project
79	KWRD	Peechi
80	KWRD	Pothundy
81	KWRD	Vazhany
82	KWRD	Walayar
83	Kerala State Electricity Board (KSEB)	Idamalayar (Eb)
84	KSEB	Cheruthoni (Eb)
85	KSEB	Errattayar (Eb)
86	KSEB	Idukki (Eb)
87	KSEB	Kallar
88	KSEB	Kulamavu (Eb)
89	KSEB	Chulliyar
90	KSEB	Kallada
91	KSEB	Moozhiyar (Kakkad) (Eb)
92	KSEB	Veluthodu (Kakkad) (Eb)
93	KSEB	Kakkayam Dam (Hep)
94	KSEB	Kosani Saddle Dam
95	KSEB	Kottagiri Saddle Dam
96	KSEB	Kuttiyad Saddle Dam
97	KSEB	Kuttiyadi Augmentation Main Dam
98	KSEB	Kuttiyadi Augmentation Spillway Dam

99	KSEB	Manjoora Saddle Dam
100	KSEB	Nayammoola Saddle Dam
101	KSEB	Near Kottagiri Saddle Dam
102	KSEB	Pambla Dam
103	KSEB	Kallarkutty (Eb)
104	KSEB	Kundala (Eb)
105	KSEB	Madupetty (Eb)
106	KSEB	R A Head Works (Ramaswami Aiyar Headworks)
107	KSEB	Anayirankal (Eb)
108	KSEB	Ponmudi (Anayirankal) (Eb)
109	KSEB	Poringalkuthu (Eb)
110	KSEB	Anathodu Flanking (Eb)
111	KSEB	Gavi (Sa Diversion) (Eb)
112	KSEB	Kakki (Eb)
113	KSEB	Kullar (Sabarigiri Aug.) (Eb)
114	KSEB	Meenar I (Sabarigiri Aug.) (Eb)
115	KSEB	Meenar Ii (Sabarigiri Aug.) (Eb)
116	KSEB	Pamba (Eb)
117	KSEB	Upper Moozhiyar (Sa) (Eb)
118	KSEB	Sengulam (Eb)
119	KSEB	Sholayar (Flanaking) (Eb)
120	KSEB	Sholayar (Main) (Eb)
121	KSEB	Sholayar (Saddle) (Eb)
122	KSEB	Vazhani
123	Karnataka Water Resources Department (KAWRD)	Almatti Dam
124	KAWRD	Bhadra Dam
125	KAWRD	Chickkahole
126	KAWRD	Devarabillikere Tank
126	KAWRD	H.B.Halli Pickup
127	KAWRD	Harangi Dam
128	KAWRD	Hemavathy Dam
129	KAWRD	Hidkal Dam
130	KAWRD	Malaprabha Dam
131	KAWRD	Mallaghatta Tank

132	KAWRD	Maskinala
133	KAWRD	Narayanapur Dam
134	KAWRD	Lakya
135	KAWRD	Hagari Bommanaha1li
136	KAWRD	Votehole Dam
137	DVC	Konar Dam
138	BBMB	Bhakra Dam
139	BBMB	Beas Dam
140	BBMB	Pandoh Dam
141	Bihar Water Resources Department (BWRD)	Kharagpur Lake
142	BWRD	Nagi
143	BWRD	Kohira
144	BWRD	Amrity
145	BWRD	Badua
146	BWRD	Srikhandi
147	BWRD	Kalmahadeo
148	BWRD	Chandan
149	BWRD	Jalkund
150	BWRD	Morway
151	BWRD	Job
152	BWRD	Kailashghati
153	BWRD	Nakti
154	BWRD	Baskund
155	BWRD	Belharna
156	BWRD	Anjan
157	BWRD	Phulwaria
158	BWRD	Orhani
159	BWRD	Upperkuil
160	BWRD	Bilasi
161	THDC	Tehri Dam
162	THDC	Koteshwar Dam
163	National Hydroelectric Power Corporation (NHPC)	Parbati III Dam
164	NHPC	Baira Dam
165	NHPC	Chamera I Dam

166	NHPC	Chamera II Dam
167	NHPC	Chamera III Dam
168	NHPC	Salal & Salal Dam
169	NHPC	Uri I
170	NHPC	Dul Dam
171	NHPC	Sewa II Dam
172	NHPC	Chutak Dam
173	NHPC	Nimo Bazgo Dam
174	NHPC	Uri II Dam
175	NHPC	Rangit Dam
176	NHPC	Teesta V Dam
177	NHPC	Tanakpura Dam
178	NHPC	Dhauliganga Dam
179	NHPC	Teesta Low III Barrage
180	NHPC	Teesta Low IV
181	Himachal Pradesh (IPH)	Sanj Dam
182	Himachal Pradesh (IPH)	Pong Dam
183	Himachal Pradesh (IPH)	Neogal
184	Himachal Pradesh (IPH)	Nathka Japri
185	Himachal Pradesh (IPH)	Malana I
186	Himachal Pradesh (IPH)	Malana II
187	Himachal Pradesh (IPH)	Larji
188	Himachal Pradesh (IPH)	Kol
189	Himachal Pradesh (IPH)	Karchham Wangtoo
190	Himachal Pradesh (IPH)	Chanju I
191	Himachal Pradesh (IPH)	Budil
192	Himachal Pradesh (IPH)	Baspa II
193	Himachal Pradesh (IPH)	Allain Duhanganj

Annexure VI

Minutes of the Meeting held on 27th February, 2020

NITI Aayog

(WR&LR Vertical)

Subject: First meeting of the Committee constituted for formulation of strategy for Flood Management Works in entire country and River Management Activities and works related to Border Areas (2020 – 23).

The first meeting of the Committee constituted for formulation of strategy for Flood Management Works in entire country and River Management Activities and works related to Border Areas (2020 – 23) was held on 27th February, 2020, at 1200 hrs in Room No. 228, NITI Aayog. The meeting was attended by CEO, NITI Aayog, Secretary, Department of Water Resources, RD & GR (D/o WR, RD & GR) , Ministry of Jal Shakti, Member Secretary, National Disaster Management Authority (NDMA), Member, Central water Commission (CWC), Joint Secretary, Ministry of Home Affairs, Director (North), Ministry of External Affairs, Experts from IIT-Roorkee and Central Water and Power Research Station (CWPRS), representatives from state of Jammu & Kashmir, Uttar Pradesh, Bihar, West Bengal, Punjab, Assam, , Tripura, and Kerala and other senior officers of D/o WR, RD &GR, CWC and NITI Aayog. The list of the participants is enclosed as **Annexure.**

At the outset, Adviser (WR), NITI Aayog welcomed all the participants and mentioned that consequent upon examination of the draft Cabinet Note on 'Flood Management and Border Areas Programme (FMBAP)' for flood management works in entire country and river management activities and works in the border areas during 2017-18 to 2019-20, the PMO had conveyed that the strategy for flood management for the next three years should be firmed up by a group led by NITI Aayog. The strategy should have clear priorities, costs and deliverables for the next three years (2020-23). In order to formulate the 'Strategy for Flood Management Works in entire country and River Management Activities and works in the Border Areas for 2020-2023' a Committee is constituted under the chairmanship of Vice Chairman, NITI Aayog. The committee is duly represented by central ministries, states and external experts. He further requested Secretary, D/o WR, RD & GR to set the context of the meeting for the participants.

Secretary, D/o WR, RD & GR introduced the subject to the participants and mentioned that flood is one of the most frequent and important natural calamity to the country. There is no year when we as a Nation have not faced the destruction of flood. Due to climate change not only the frequency but also the magnitude of flood has increased over the years. Floods are natural phenomenon so they cannot be prevented but can be managed. We have to understand the new concept of living with the floods. He further indicated that there are number of measures to manage funds which

include both structural and non-structural measures. In structural measures, perhaps the best cushion for floods are dams but now we have to understand that due to environmental constraints, it is not easy to build new dams in India. Other structural measures like embankments can be adopted but they should not be taken up indiscriminately. Although department is now focusing on non-structural measures like flood plain zoning, catchment area treatment plans etc. which are very important but are not getting enough attention and importance. He also asserted that department has come long way in the case of flood forecasting and early warning system. Now the flood warnings are issued 72 hrs before the event which was earlier 24 hrs. Also, department has started to use and provide inundation maps for better identification of submerged areas. He further requested Joint Commissioner (FM) to make a presentation to the committee.

Joint Commissioner (FM), DoWR, RD & GR made a presentation and briefed the committee about the general facts of flood, types of floods, structural & nonstructural measures of flood management which includes dams, embankments, flood forecasting, flood plain zoning, etc., components of flood management & border areas programme (FMBAP) and performance of the scheme. He in detailed discussed the annual damages caused by the floods and extent of problem of flood in India. He further moved on to the FMBAP scheme, its coverage, funding mechanism and progress.

After the presentation, chairman of the committee Vice Chairman, NITI Aayog invited the committee members, representatives of the states and external experts to express their views.

Member Secretary, NDMA taking the lead expressed that there are number of laws and guidelines to define and mitigate the risk of floods. But these laws can be effective only if they are implemented with high level administrative will and skill. In order to encourage states to take up flood management measures like flood plain zoning (only Jammu & Kashmir, Uttarakhand and Jharkhand have Flood Plain Zoning), they should be provided with incentives which may include financial incentives.

Deputy Secretary, Water Resources department, Government of Kerala highlighted as per the FMB guidelines, Projects amounting to Rs.40 Crore or above would be considered as per the guidelines laid down under FMP. Due to typical topography of the states, the construction of storage structures amounting to Rs.40 Crore or above is mostly inconceivable. In case of coastal protection works, the guidelines mandate that prior to sanction of works under FMP and necessary clearances shall be obtained from the State Coastal Zone Management Authority (CZMA). Though the state had approached its authority for clearance, it was informed that the clearance could not be issued unless EIA is done (Environmental Impact Assessment) which gets carried out for one year. If the guidelines of FMP can be modified by relaxing the minimum total amount for a project to be funded in case of river training works, works on embankments, State of Kerala would be able to derive funds under FMP. ln the case of coastal erosion works also, the state would enjoy benefits of the central funds much more than from its own plan schemes if necessary relaxation can be made by the (CZMA)for those works which are only reformation

in nature. Answering the query, Secretary, DoWR, RD & GR mentioned that projects should be taken up for the entire stretch of the rivers for proper management of floods. The comprehensive projects can go up to the prescribed amount of Rs 40 cr. Further, Vice Chairman, NITI Aayog instructed to call a representative of Coastal Regulatory Zone Authority in the next meeting of committee.

Chief Engineer, Irrigation, Government of Uttar Pradesh highlighted that in Uttar Pradesh projects of flood management are delaying due to delayed and phase wise funding from the DoWR, RD & GR. Another main reason for the delay is the cumbersome procedure of getting approvals from number of departments of central government. Responding to the comment, Vice Chairman, NITI Aayog calls for the rationalization of funding and approval process of the ministry.

Joint Secretary, I&W Department, Government of West Bengal stressed on the two issues faced by the state in flood management. Firstly, the high density of population in flood plain zone doesn't allow the state government to undertake flood plain zoning. Secondly, in last four years, state is able to save human and livestock lives by shifting them to safer places in the event of flood but they are not able to find out the panacea for the flood related damages. Responding to issues, Secretary, DoWR, RD & GR asserted that in order to minimize the flood related damages, it is necessary to leave the room of the river and state should enact the law on flood plain zoning on priority.

Chief Engineer, Water Resources department, Government of Punjab raised the issue that due to lack of central assistance some heavily invested projects in Punjab are stalled. He requested the Committee to consider these projects for continuation. The Vice Chairman, NITI Aayog indicated that it should be considered.

Joint Secretary, Ministry of Home Affairs informed that post flood relief measures are now entirely under the perview of Ministry of Home Affairs. Therefore, it is necessary to have a synchronized database for the damages caused by the floods. The Vice Chairman, NITI Aayog also calls for the collection of proper data of the damages caused by the flood. The Chief Engineer (CWC) informed that in 2012, an expert committee was established under the chairmanship of Chairman (CWC) to provide better estimates of the damages occurred due to floods in India and that committee is due to submit its report in next two months. Vice Chairman NITI Aayog instructed CWC to submit a copy of report to this committee and may however provide the Terms of Reference of the committee established to assess estimates of damages occurred due to floods to Water Resources Vertical, NITI Aayog.

Scientist (SG and DGM), ISRO informed the committee that ISRO has collected the flood foot prints all over the country and also undertaking the basin wise studies to study the patterns of flood in the basins. ISRO is also assisting DoWR, RD & GR through National Institute of Hydrology in collecting data on floods.

Professor, Deepak Khare from IIT, Roorkee indicated that there is need to focus on the Research and Development in order to find out the new technologically advanced measures to control

flood. He also asserted that DoWR, RD & GR should conduct a study on the flood events of last 10 years to find out the commonalities among them and focus on those to solve the problem. He further requested to study the changing climate and land use patterns to predict floods in near future.

Summing up the discussion, Vice Chairman, NITI Aayog emphasized that problem of flood is a much vast and deep rooted then it is represented in general terms. In the changing climatic and environmental scenario flood management is not limited to some flood control measures but it needs to be taken up in holistic manner which includes redefining of roles of various stakeholders and changes in institutional set ups. This committee should provide the comprehensive and holistic solution to the problem of flood management in India.

After detailed discussions, the following decisions were taken:

1. The CWC will submit a copy of the report of the expert committee established to provide estimates of damages occurred due to floods to this committee and for present it may provide the Terms of Reference of the committee to Water Resources Vertical, NITI Aayog.

(Action: CWC, Ministry of Jal Shakti)

2. CWC has recently done a presentation on flood forecasting and other non- structural measures to Parliamentary Advisory Committee. CWC should provide this presentation to Water Resources Vertical, NITI Aayog. CWC should also provide a brief note on the procedure of flood forecasting and estimates about the hydrological observation stations needed for accurate forecasting in India.

(Action: CWC, Ministry of Jal Shakti)

3. D/o WR, RD & GR may conduct a study and find out that how flood plain zoning is defined and implemented in other countries like Egypt, United States of America, Brazil and China.

(Action: D/o WR, RD & GR, Ministry of Jal Shakti)

4. CWC and NITI Aayog should examine the process of granting the clearance to the states for flood management projects and find out the ways to rationalize the whole process. CWC should make a presentation on the above findings in next meeting.

(Action: CWC, Ministry of Jal Shakti & NITI Aayog)

5. The 8 state namely West Bengal, Bihar, Assam, Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Kerala and Tamil Nadu (having highest fund allocation in FMP Component of FMBAP scheme) should make a presentation in the next meeting on the measures taken by them and the protection from flood achieved out of this investment. D/o WR, RD & GR should coordinate with these states for the presentation, so the strategy may be formed or 2020 to 2023.

(Action: D/o WR, RD & GR, Ministry of Jal Shakti)

6. CWC and Ganga Flood Control Commission should make a presentation to the committee and recommend that how the departments working in silos at centre and state level should come together to form long term strategy to control and mitigate floods in India.

(Action: CWC and Ganga Flood Control Commission)

7. D/o WR, RD & GR in consultation with WR Vertical NITI Aayog should identify some important projects for continuation which are foreclosed by State under FMBAP scheme. D/o WR, RD & GR should also look into the guidelines/constraints which force the states to foreclose the projects and try to simplify these guidelines.

(Action: D/o WR, RD & GR, Ministry of Jal Shakti, NITI Aayog)

8. NDMA has prepared the guidelines on Floods and urban floods in 2008. NDMA should make a presentation to the committee on these guidelines, so the guidelines' suitability for adoption by the committee may be considered.

(Action: NDMA)

9. A representative of Coastal Regulatory Zone Authority (CRZA) should be invited to the next meeting of the committee who should provide details on the clearance procedures of Flood Management Projects.

(Action: Water Resources Vertical, NITI Aayog)

The meeting ended with vote of thanks to the chair.

List of Participants in the 4th Meeting of Pmksy Council Held Under the Chairmanship of Ceo, Niti Aayog on 14.12.2018 in Niti Aayog, New Delhi

S.No.	Name	Designation and Organization
1	Dr. Rajiv Kumar, Vice Chairman, NITI Aayog	In Chair
2	Shri. Amitabh Kant	CEO, NITI Aayog
3	Shri. U.P. Singh	Secretary, DoWR, RD & GR, Ministry of Jal Shakti
4	Shri. G.V.V. Sarma	Member Secretary, NDMA
5	Shri R.K. Gupta	Member, CWC
6	Shri Avinash Mishra	Adviser, WR & LR, NITI Aayog
7	Shri Sanjeev Kumar Jindal	Joint Secretary, MHA
8	Shri Amit A. Shukla	Director (North), MEA

9	Shri D. Sengupta	Joint Secretary, I&W Department, Government of West Bengal
10	Shri Padma Kant Jha	S.E. Water Resources department, Bihar
11	Ms. Mrunmai Joshi	Deputy Secretary, Water Resources department, Kerala
12	Shri G. Srinivasa Rao	Associate Director (DRR), ISRO
13	Dr. V.M. Chowdary	Scientist (SG and DGM), ISRO
14	Shri B.K.Kanjer	Chief Engineer, CWC
15	Shri. A.K. Singh	Chief Engineer Irrigation, U.P.
16	Shri. Sanjiv Gupta	Chief Engineer, Water Resources, Punjab
17	Shri. Ashok Sharma	Chief Engineer I&W Department, Jammu & Kashmir
18	Shri Bishu Kumar. Debbarma	Chief Engineer, Water Resources, Tripura
19	Shri Abani Hazarika	Chief Engineer, Water Resources, Assam
20	Shri Charu Chandra Mishra	E. E. Water Resources department, Bihar
21	Shri Khanindra Barman	AEE, WRD, Assam
22	Shri Rakesh Toteja	Joint Commissioner, DoWR, RD & GR, Ministry of Jal Shakti
23	Shri Sharad Kumar Kaushal	Deputy Commissioner, DoWR, RD & GR, Ministry of Jal Shakti
24	Shri Piyush Kumar	Director, CWC, Ministry of Jal Shakti
25	Shri Sharad Chandra	Director, CWC, Ministry of Jal Shakti
26	Shri Upananda Rath	Deputy Director, DoWR, RD & GR, Ministry of Jal Shakti
27	Shri Harish Kumar Chauhan	Liaison Officer, WRD, Arunachal Pradesh
28	Shri N.K. Vel	Scientist- D, NITI Aayog
29	Shri Gopal Saran	Scientist- C, NITI Aayog
30	Shri Venkat Angina	RA, NITI Aayog
31	Ms. Arunima Chandra	YP, NITI Aayog
32	Ms. Aakanksha Sharma	YP, NITI Aayog
33	Dr. Namrata Singh Panwar	YP, WR & LR, NITI Aayog

Annexure VII

Minutes of the Meeting held on 27th May, 2020

NITI Aayog

(WR&LR Vertical)

Subject: Second meeting of the Committee constituted for formulation of strategy for Flood Management Works in entire country and River Management Activities and works related to Border Areas (2020 – 23).

The second meeting of the Committee constituted for formulation of strategy for Flood Management Works in entire country and River Management Activities related to Border Areas (2020 – 23) was held under the chairmanship of V.C. NITI AAYOG through video conferencing on 27th May, 2020, at 1500 hrs in Room No. 126, NITI Aayog. The meeting was attended by Member (Agri & Water Resources), NITI Aayog, Secretary, Department of Water Resources, RD & GR (D/o WR, RD & GR), Ministry of Jal Shakti in person and senior officers from National Disaster Management Authority (NDMA), Central water Commission (CWC), Experts from IIT-Roorkee and Delft Institute Netherland, representatives from state of Uttar Pradesh, Bihar, Assam, Himachal Pradesh and Kerala connected through Video Conferencing. The list of the participants is enclosed as **Annexure.**

At the outset, Adviser (WR), NITI Aayog welcomed all the participants and briefed them on the progress of work of the committee. He mentioned that the basic objective of the committee is to frame a strategy for flood management in India for next three years (1st April 2020 to 31st March 2023). The first meeting of the committee was held on 27th February 2020 wherein it was deliberated that it is very important to organise the unstructured flood management guidelines in the country. Non-structural measures should be given due focus and benchmarking should be done with other developed countries. Flood cushioning should be provided in the new dams and if possible, in existing dams too. Thereafter he requested Ministry of Jal Shakti to make a presentation on River Management activities in Border Area.

Commissioner (FM), DoWR, RD & GR made a presentation on the river management activities in the Border area. India shares its border with 5 countries where trans-boundary rivers flow. These nations are China, Pakistan, Nepal, Bhutan and Bangladesh. In respect of China, Nepal and Bhutan we are lower riparian states and in case of Pakistan and Bangladesh, we are upper riparian states. He explained that here we need to undertake the works which are strategically important at times may not be priority to the states. Subsequently, Commissioner (FM) briefed committee on various components of the programme, on-going projects, funding mechanisms for states and UTs, working and functions of lateral organizations like Ganga Flood Control Commission which provide long term plans for managing flood in Ganga Basin. He further indicated that

due to some restrictions in the current guidelines, Ministry is not able to fund the projects which are on the river originating from the Nepal other than Kosi and Gandak. Elaborating the whole issue Secretary (D/o WR, RD & GR) indicated that these trans- boundary river projects do not give large benefits to the states, therefore there is always uncertainty that which agency is going to fund them. But these projects are important to develop the atmosphere of trust and belief with Nepal and other neighbouring countries. Therefore, the new guidelines need to be formulated to accommodate logically vulnerable stretches on international rivers. The Vice Chairman, NITI Aayog and the Chairman of the committee instructed to constitute a committee under Secretary Water Resources where in Commissioner (FM) will provide a tabular comparison of the existing guidelines and the revised guidelines and reasons for the change in guidelines. The committee will submit its report in next 15 days.

Secretary (D/o WR, RD & GR) emphasized on the issue that meager money is spent in the country on the flood mitigation. We as a country spend more money on relief measure than the mitigation. In the response of this, Member (RC), Water Resources, NITI Aayog stated that this time 15th Finance Commission under Disaster Management head has made recommendation in two parts- 20 percent (5797 Crore) of the total fund is allocated under Disaster Mitigation and 80 percent (23186 Crore) is allocated under disaster response for states. He further suggested that Ministry should evaluate the existing schemes, point out that whether these schemes should continue and suggest new schemes/guidelines.

The Vice Chairman, NITI Aayog instructed to constitute a sub- committee under Secretary (D/o WR, RD & GR), Ministry of Jal Shakti, wherein Adviser (WR&LR) will be a member other member including the States representatives may be decided by the Secretary WR as per requirement. The group will evaluate the ongoing schemes and suggest prioritized schemes, new guidelines for RMBAP, structural measures (FMP and FMBAP) and non-structural measure for flood management in country. The committee will submit its report in next 15 days.

The next presentation was made by Joint Secretary, NDMA on the guidelines prepared by NDMA for the flood management in urban areas and whole country. Vice Chairman, NITI Aayog instructed the officials from NDMA to submit the guidelines, any suggestive changes and new areas of work to the committee for consideration.

Next presentation was made by Central Water Commission on non-structural measures for flood mitigation and management. In the presentation CWC emphasized the efficacy of non-structural measures like Flood plain zoning, flood forecasting in mitigation of flood. Flood Plain Zoning reduces the flood risk by 30-40 percent. There have been Global examples like Japan and US which have used flood plain zoning and other non- structural measures to manage floods. CWC is also collaborating with M/s Google Inc., to provide inundation maps and alerts based on the Flood Forecast available in CAP platform using high quality Digital Terrain Models available with Google using Artificial Intelligence and Machine Learning. The system started functioning from 2018 when inundation alerts were provided for Patna Gandhighat forecast stations. This

has expanded to around 11,000 sq.km. covering 7 FF stations (Patna Gandhighat & Kahalgaon in Bihar, Neamatighat, Tezpur, Guwahati & Goalpara in Assam and Ayodhya in Uttar Pradesh) during 2019. This is likely to be covered to all level forecast stations during the next few years. CWC further indicated that there is 90 percent accuracy in the flood forecast and duration of forecast has increased from 24 hrs to 72 hrs. Also, now we have 325 flood forecasting stations and 1600 hydrological stations in India.

Secretary (D/o WR, RD & GR), Ministry of Jal Shakti indicated that India has multipurpose dams which are not categorized into the flood control dams or irrigation dams as per the practice in developed nations. Therefore, it is very difficult for the states to prepare emergency action plans for these dams. On this point Vice Chairman NITI Aayog instructed CWC to categorize the all 5500 large dams in India according their use in flood control, irrigation and other purposes so that emergency action plans can be prepared by the states accordingly.

State of Assam in its presentation to the committee stated that Assam is the worst flood affected state in the Nation and even then, since 2014 no new scheme has been sanctioned. Structural measures are very much necessary for Assam to save it from the destruction of floods; therefore, central assistance to Assam should increase significantly.

State of Himachal Pradesh in its presentation requested to the committee to clear some very important projects of the state under FMBAP.

Dr. Biswa Bhattacharya, Professor, Delft Institute Netherland indicated globally countries provide flood forecasting 3-4 days prior to the event. CWC has increased its duration from 24 hrs to 72 hrs but still we need to move ahead to 14 days flood forecasting to mitigate maximum losses from the flood also Digital Elevation Models can be developed and he will happy to assist CWC in this regard.

Member (RC), Water Resources NITI Aayog indicated that inputs should be taken from states and other experts to form an inclusive strategy for flood management in India. He further suggested that tree horticulture should also be adopted in flood plains to minimize the loss due to floods. Suggestions in this regard may be taken from Agriculture Ministry. He also emphasized on the importance of lake and wetlands in both rural and urban areas for flood management and water security. He further suggested the proposed sub - committee may consider, National Bureau of Soil Survey and Land Use planning (NBSS&LUP) maps and explore the possibility of using their work in flood zone identification and creation of inundation maps.

After detailed discussions, the following decisions were taken:

1. Commissioner (FM) Mo Jal Shakti will provide a tabular comparison of the existing guidelines and the revised guidelines and reasons for the change in guidelines under the River Management Activities in Border Area Programme to the committee headed by secretary DoWR,RD&GR.**(Timeline: 10th June 2020)**

(Action: D/o WR, RD & GR, Ministry of Jal Shakti)

2. Constitute a Sub- committee under Secretary (D/o WR, RD & GR), Ministry of Jal Shakti with Adviser (WR&LR) NITI as member and other Members as per the requirements from the States, CWC, other Central organisations etc. Sub-committee will evaluate the ongoing schemes and suggest (1) Prioritised schemes both FMP and FMBAP for funding during 2020-2023. Also, sub-committee will suggest new guidelines for RMBAP, structural measures and non-structural measure for flood management in country. **(Timeline: 20th June 2020)**

(Action: D/o WR, RD & GR, Ministry of Jal Shakti)

3. CWC is to categorize the all 5500 large dams in India according to their use in flood control, irrigation and other purposes so that emergency action plans can be prepared by the states accordingly. **(Timeline: 15th June 2020)**

(Action: CWC, Ministry of Jal Shakti)

4. Expert Consultation will be held under the chairmanship of Secretary (D/o WR, RD & GR), Ministry of Jal Shakti and inputs to be submitted to the committee. **(Timeline: 15th June 2020)**

(Action: D/o WR, RD & GR, Ministry of Jal Shakti)

5. Inputs (explicit suggestions and lessons from the past) will be collected from the states to form the strategy **(Timeline: 15th June 2020)**

(Action: D/o WR, RD & GR, & WR&LR, NITI Aayog)

6. National Bureau of Soil Survey and Land Use planning's (NBSS&LUP) should be contacted and possibility should be explored of using their work in flood zone identification and creation of inundation maps. **(Timeline: 15th June 2020)**

(Action: CWC and Commissioner FM Mo Jal Shakti)

7. NDMA will submit its guidelines related to flood management, any suggestive changes in the guidelines and new areas of work to the committee for consideration. **(Timeline: 15th June 2020)**

(Action: NDMA)

The meeting ended with vote of thanks to the chair.

List of participants in the second meeting of the committee constituted for formulation of strategy for flood management works in entire country and river management activities and works related to border areas (2020 – 23)

S.No.	Name	Designation and Organization
1.	Dr. Rajiv Kumar, Vice Chairman, NITI Aayog	In Chair
2.	Dr. Ramesh Chand	Member, NITI Aayog
3.	Shri. U.P. Singh	Secretary, DoWR, RD & GR, Ministry of Jal Shakti
4.	Shri. Sandip Kumar	Joint Secretary, NDMA
5.	Shri Avinash Mishra	Adviser, WR & LR, NITI Aayog
6.	Shri Atul Jain	Commissioner (FM), DoWR, RD & GR, Ministry of Jal Shakti
7.	Shri Hazarika	Additional Chief Secretary Assam
8.	Shri Rakesh Toteja	Joint Commissioner, DoWR, RD & GR, Ministry of Jal Shakti
9.	Shri G. Srinivasa Rao	Associate Director (DRR), ISRO
10.	N kumar Vel	Scientist D NITI AAYOG
11.	Sh Padma Kant Jha	SE Bihar WRD
12.	Ms. Arunima Chandra	YP, NITI Aayog

Designed by yaap