INDIAN FLOOD MANAGEMENT:

A REPORT ON INSTITUTIONAL ARRANGEMENTS

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BACKGROUND

Asia and the Pacific is the world's most disaster-prone region, registering the largest number of people affected, as well as the largest number of people killed, by disasters between 2002 and 2011. Over the past three decades, the frequency of natural disasters has increased globally but the sharpest increase has been in the Asian and Pacific region (see figure F.5-1) partly as a result of better reporting, but also because of increasing exposure and vulnerability. Exposure to hazards has multiplied with the growth of unplanned urbanization and the concentration of people and economic activities in hazard-prone areas. (UNESCAP, 2013)

This report is primarily a compilation of the information about institutional arrangements in India about Flood Management. It also talks about briefly the overall disaster management framework of India as well as some major flood disasters in India since year 2000. It uses different secondary data in the form of published papers, articles and reports from various governmental agencies, Research Institutions, NGOs and International Organizations. All the maps/ pictures / figures and tables are also from various secondary resources.

The idea of compiling this information as a report is to provide one single information source for research and scientific community regarding Indian Flood Management.

DISASTER MANAGEMENT ACT 2005

The Disaster Management Act, 2005 came into the statute book on 26 December 2005 by a Gazette notification, exactly on the first anniversary of the devastating tsunami of 2004, which killed nearly 13,000 people in India alone and affected 18 million people. The Act provides a legal and institutional framework for "the effective management of disasters and for matters connected therewith or incidental thereto." It provides for establishment of National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA) and District Disaster Management Authorities (DDMA) at the National, State and District levels with adequate financial and administrative powers and creation of the National Institute of Disaster Management (NIDM) with the mandate of undertaking training and capacity building, Develop Training Modules on various aspects of Disaster management, Undertake Research and Documentation, Formulate and

implement comprehensive HRD Plan covering all aspects of DM, Provide assistance in national level policy formulation and Provide assistance to state governments and State Training Institutions. The act also provides guidelines for creation of National Disaster Response Fund, National Mitigation Fund, Establishment of funds by State Government and Allocation of funds by Ministries and Departments for Emergency procurement. The act also provides for establishment of National Disaster Response Force (NDRF). (SAARC-IDKN, 2014)

DISASTER MANAGEMENT- INSTITUTIONAL ARRANGEMENTS IN INDIA

The Disaster Management Act 2005 has provided the legal and institutional framework for disaster management in India at the national, state and district levels. In the federal polity of India the primary responsibility of disaster management vests with the State Governments. The Central Government lays down policies and guidelines and provides technical, financial and logistic support while the district administration carries out most of the operations in collaboration with central and state level agencies.

In the Central Government there are existing institutions and mechanisms for disaster management while new dedicated institutions have been created under the Disaster Management Act of 2005.

The Cabinet Committee on Management of Natural Calamities (CCMNC) oversees all aspects relating to the management of natural calamities including assessment of the situation and identification of measures and programmes considered necessary to reduce its impact, monitor and suggest long term measures for prevention of such calamities, formulate and recommend programmes for public awareness for building up society's resilience to them. The Cabinet Committee on Security.(CCS) deals with the matters relating to nuclear, biological and chemical emergencies

The National Crisis Management Committee (NCMC) under the Cabinet Secretary oversees the Command, Control and Coordination of the disaster response.

The Disaster Management Act, 2005 has created new institutions at the national, state, district and local levels. The new institutional framework for disaster management in the country is as under:

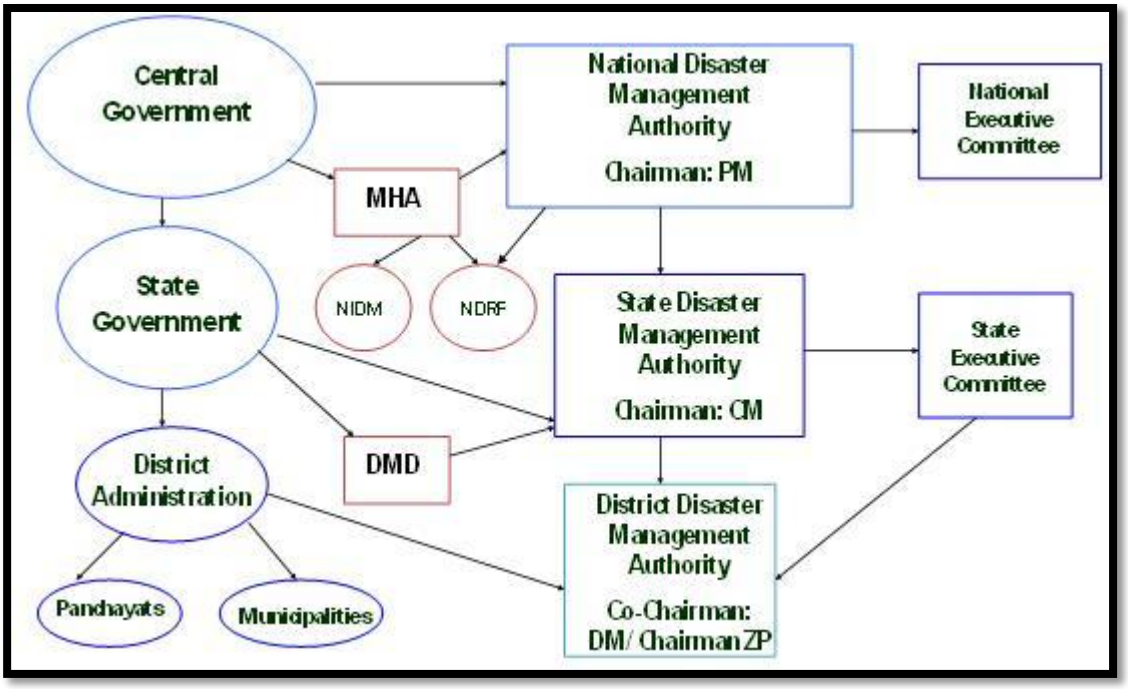


Figure 1: Semantic Model for Indian Institutional Arrangements for Disaster Management

The National Disaster Management Authority (NDMA) under the Chairmanship of the Prime Minister is the apex body responsible for laying down policies, plans and guidelines for disaster management and for coordinating their enforcement and implementation throughout the country. The policies and guidelines will assist the Central Ministries, State Governments and district administration to formulate their respective plans and programmes. NDMA has the power to approve the National Plans and the Plans of the respective Ministries and Departments of Government of India. The general superintendence, direction and control of National Disaster Response Force (NDRF) are vested in and will be exercised by the NDMA.

The National Executive Committee (NEC) is mandated to assist the NDMA in the discharge of its functions and further ensure compliance of the directions issued by the Central Government. The NEC comprises of the Union Home Secretary as the Chairperson, and the Secretaries to the GOI in the Ministries/Departments of Agriculture, Atomic Energy, Defence, Drinking Water Supply, Environment and Forests, Finance (Expenditure), Health, Power, Rural Development, Science and Technology, Space, Telecommunications, Urban Development, Water Resources and the Chief of the Integrated Defence Staff of the Chiefs of Staff Committee as members. Secretaries in the Ministry of External Affairs, Earth Sciences, Human Resource Development, Mines, Shipping,

Road Transport & Highways and Secretary, NDMA are special invitees to the meetings of the NEC. The National Executive Committee is responsible to prepare the National Plan and coordinate and monitor the implementation of the National Policy and the guidelines issued by NDMA.

The Ministry of Home Affairs (MHA) in the Central Government has the overall responsibility for disaster management in the country. For a few specific types of disasters the concerned Ministries have the nodal responsibilities for management of the disasters, as under:

Table1: Disaster Types and Responsible Federal Agencies

Type of Disaster	**Responsible Federal Agency**
Drought	Ministry of Agriculture
Epidemics & Biological Disasters	Ministry of Health and Family Welfare
Chemical Disasters	Ministry of Environment & Forests
Nuclear Disasters	Ministry of Atomic Energy
Air Accidents	Ministry of Civil Aviation
Railway Accidents	Ministry of Railways

The National Institute of Disaster Management (NIDM) has the mandate for human resource development and capacity building for disaster management within the broad policies and guidelines laid down by the NDMA. NIDM is required to design, develop and implement training programmes, undertake research, formulate and implement a comprehensive human resource development plan, provide assistance in national policy formulation, assist other research and training institutes, state governments and other organizations for successfully discharging their responsibilities, develop educational materials for dissemination and promote awareness among stakeholders in addition to undertake any other function as assigned to it by the Central Government

The National Disaster Response Force (NDRF) is the specialized force for disaster response which works under the overall supervision and control of the NDMA.

At the State Level the State Disaster Management Authority (SDMA), headed by the Chief Minister, lays down policies and plans for disaster management in the State. It is also responsible to coordinate the implementation of the State Plan, recommend provision of funds for mitigation

and preparedness measures and review the developmental plans of the different departments of the State to ensure integration of prevention, preparedness and mitigation measures. The State Disaster Management Department (DMD) which is mostly positioned in the Revenue and relief Department is the nodal authority.

In the district level the District Disaster Management Authority (DDMA) is headed by the District Magistrate, with the elected representative of the local authority as the Co-Chairperson. DDMA is the planning, coordinating and implementing body for disaster management at district level. It will, inter alia prepare the District Disaster Management Plan and monitor the implementation of the National and State Policies and the National, State and the District Plans. DDMA will also ensure that the guidelines for prevention, mitigation, preparedness and response measures laid down by the NDMA and the SDMA are followed by all departments of the State Government at the district level and the local authorities in the district.
The Local Authorities both the rural local self-governing institutions (Panchayati Raj Institutions) and urban local bodies (Municipalities, Cantonment Boards and Town Planning Authorities) These bodies will ensure capacity building of their officers and employees for managing disasters, carry out relief, rehabilitation and reconstruction activities in the affected areas and will prepare DM Plans in consonance with guidelines of the NDMA, SDMAs and DDMAs. (SAARC-IDKN, 2014)

FLOOD MANAGEMENT IN INDIA

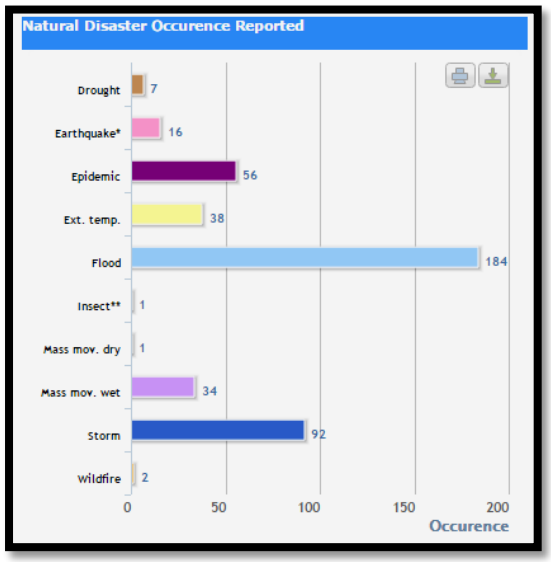
Introduction

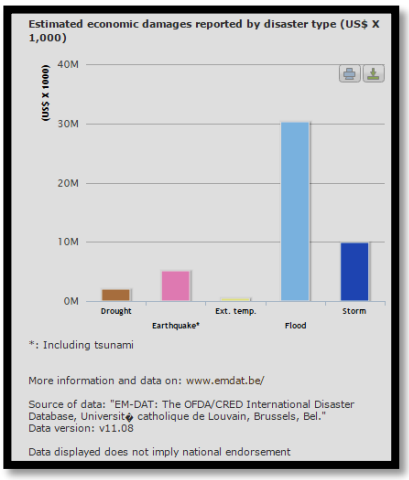
Floods have been recurrent phenomenon in many parts of India, causing loss of lives and public property and bringing untold misery to the people, especially those in the rural areas. There is also a larger economic impact, as they derail economic activities, thus affecting growth. Indian continent has peculiar climatic conditions since it has floods in some parts whereas drought in other parts. Over the years, several expert Committees have studied the problems caused by floods and suggested various measures for their management to the Government. However, despite the various steps undertaken over the last five decades, the trend of increasing damage and devastation brought by floods has posed a challenge to the Government as well as to the people. The

approaches to flood management presently exercised in India also need to give a re-look to have an integrated strategy for policy and management related to floods. (INDIA-WRS-NRSC, 2014)

Flood Disasters – Most Harmful to Indian Economy

According to Preventionweb, UNISDR, between the period of 1980-2010 which is shown in Figure 2. Floods are the most common natural disaster which occurred in India. Floods have caused maximum economic damage to Indian economy in comparison to other disasters during this period. Percentage of people affected is also second highest after drought. (Preventionweb, UNISDR)





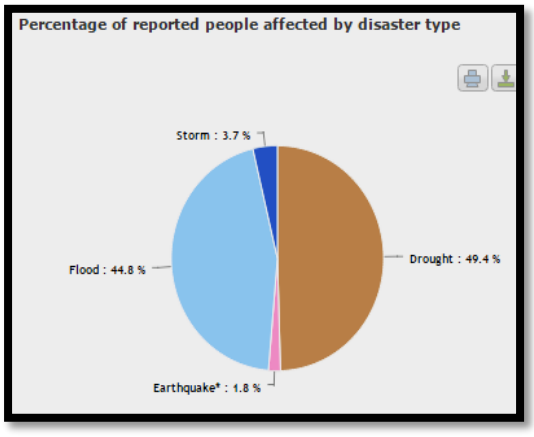


Figure 2: Statistical charts for Disasters in India between 1980-2010; Source: (Preventionweb, UNISDR)

River Systems and Associated Flood Problems

The rivers in India can be broadly divided into the following four regions for a study of flood problem.

(1) Brahmaputra Region;

(2) Ganga Region;

(3) North West Region ; and

(4) Central India and Deccan region.

Brahmaputra River Region:

This region consists of the rivers Brahmaputra & Barak and their tributaries covering seven states Assam, Arunachal Pradesh, Meghalaya, Mizoram, Northern parts of West Bengal, Manipur, Tripura and Nagaland. The catchments of these rivers receive very heavy rainfall ranging from 110 cm. to 635 cm. a year which occurs mostly during the months of May / June to September. As a result, floods in this region are severe and quite frequent. Further, the rocks of the hills, where these rivers originate are fragile and susceptible to erosion thereby causing exceptionally high silt charge in the rivers. In addition, the region is subject to severe and frequent earthquakes which cause numerous landslides in the hills and upset the regime of the rivers. The predominant problems in this region are the flooding caused by spilling of rivers over their banks, drainage congestion and tendency of some of the rivers to change their courses. In recent years, the erosion along the banks of the Brahmaputra has assumed serious proportions.

Ganga River Region:

The river Ganga and its numerous tributaries, of which important ones are the Yamuna, the Sone, the Ghaghra, the Gandak, the Kosi and the Mahananda, constitute this river region. It covers ten states of Uttaranchal, Uttar Pradesh in its basin area , Jharkand, Bihar, South and Central parts of West Bengal, parts of Haryana , Himachal Pradesh, Rajasthan, Madhya Pradesh and Delhi. The normal annual rainfall in this region varies from 60 cm to 190 cm of which more than 80% occurs during the south west monsoon. The rainfall increases from West to East and from South to North.

The flood problem is mostly confined to the areas on the northern bank of the river Ganga. The damage is caused by the northern tributaries of the Ganga by spilling over their banks and changing

their courses. Even though the Ganga is a mighty river carrying huge discharges of 57,000 to 85,000 cumec (2 to 3 million cusec), the inundation and erosion problems are confined to relatively few places. In general, the flood problem increases from the West to the East and from South to North. In the North Western parts of the region and some eastern parts, there is the problem of drainage congestion.

The flooding and erosion problem is serious in the States located in the downstream. In recent years some States which were not traditionally flood prone have also experienced some incidents of heavy floods.

North West River Region:

The main rivers in this region are the Sutlej, the Beas, the Ravi, the Chenab and the Jhelum, the tributaries of Indus, all flowing from the Himalayas. These carry quite substantial discharge during the monsoon and also large volumes of sediment. They change their courses frequently and leave behind tracts of sandy waste. The region covers the State of Jammu and Kashmir, Punjab and parts of Himachal Pradesh, Haryana and Rajasthan.

Compared to the Ganga and the Brahmaputra river region, the flood problem is relatively less in this region. The major problem is that of inadequate surface drainage which causes inundation and water logging over vast areas.

Central India and Deccan Region:

The important rivers in this region are the Narmada, the Tapi, the Mahanadi, the Godavari, the Krishna and the Cauvery. These rivers have mostly well-defined stable courses. They have adequate capacity within the natural banks to carry the flood discharge except in the delta area. The lower reaches of the important rivers on the East Coast have been embanked, thus largely eliminating the flood problem. (INDIA-WRS-NRSC, 2014)

Flood Prone Areas in India

National Flood Commission (RBA) -1980 assessed the total flood prone area in the country, shown in Figure 3, as 40 m.ha which included the unprotected flood area of 33.516 m ha and the balance as protected area. Subsequently, the Working Groups on Flood Management for X and XI Plans assessed the flood prone area in the country as 45.64 m ha. (INDIA-WRS-NRSC, 2014)

Figure 3: Flood Prone Areas of India (Source: INDIA-WRS-NRSC, 2014)

Legal Provisions

The subject of flood control, unlike irrigation, does not figure as such in any of the three legislative lists included in the Constitution State list, Union list and concurrence list 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) reads 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 thus 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. Therefore, the subject "flood management" falls within the purview of the States. The schemes for flood control are planned, investigated and implemented by the States as per priorities within the State with their own resources and the role of central government is technical, advisory, catalytic and promotional in nature. (Planning Commission, 2011)

Institutional Arrangements

In India, a two tier system of flood management exists as briefly described below:

State and Central Government Mechanisms

Central Water Commission (CWC) – The Government of India set up Central Water Commission as presently named in 1945 for achieving the goal of furthering and promoting measures of flood control, conservation and utilization of water resources throughout the country in the areas of beneficial uses, irrigation and hydropower generation, flood management and river conservation. As a national apex engineering organisation in the field of water resources development, the CWC with its vast experience gained in its strides towards progress in more than six decades, has developed considerable know-how in planning, investigation, management and design of water resources development schemes and made valuable contribution in the country's remarkable progress in this field besides sharing the expertise with developing nations of the world.

Brahmaputra Board – The Government of India set up Brahmaputra Board under Brahmaputra Board Act, 1980 (46 of 1980) under the then Ministry of Irrigation (now Ministry of Water Resources) The jurisdiction of Brahmaputra Board includes all NE States in Brahmaputra and Barak Basin. The main functions of Brahmaputra Board are as under:

- Survey and investigations in Brahmautra and barak valley.
- Preparation of master plans to control floods, bank erosion, improvement of drainage system.
- Preparation of DPRs for dams and other projects
- Standard specifications for construction operation and maintenance of dams.
- Construction of multipurpose dams and maintenance thereof.
- Any other function for implementation of Brahmaputra Board Act-1980.

Brahmaputra Board prepared master plans for the flood management for river Brahmaputra and Barak. Besides this, the Board has undertaken survey and investigations for preparation of master plans for tackling the problems of flood, erosion and drainage congestion including DPRs for multipurpose projects.

Ganga Flood Control Commission - The Ganga Flood Control Commission (GFCC) was set up by Government of India in 1972 for preparation of comprehensive plan of flood control for Ganga Basin and to draw out a phased coordinated programme of implementation of works and monitoring & appraisal of flood management schemes of Ganga basin States. The GFCC has prepared comprehensive plans of flood management of the 23 sub-basins in the Ganga Basin besides drawing out a phased programme of implementation of these works to proper standards, examination and monitoring of various flood management schemes in the Ganga Basin States.

Farakka Barrage Project Authority – The Farakka Barrage Project Authority carry out anti-erosion and river bank protection works in its jurisdiction in near river vicinity of the Barrage.

National Disaster Management Authority (NDMA) - For prevention and mitigation effects of disasters including flood disasters and for undertaking a holistic, coordinated and prompt response to any disaster situation, the Government of India has set up a National Disaster Management Authority (NDMA) in 2005 under the Chairmanship of Hon'ble Prime Minister of India.

Indian Meteorological Department - The IMD established in 1875, is responsible for the National Meteorological Service and the principal government agency in all matters relating to meteorology, seismology and allied subjects. For the convenience of administrative and technical control, there are six Regional Meteorological Centres (RMCs) which includes operational units of flood meteorological offices (FMOs).

National Remote Sensing Agency- The Department of Space has established a Decision Support Centre (DSC) at National Remote Sensing Agency (NRSA) under the Indian Space Research Organisation's (ISRO) disaster management support (DMS) programme. DSC is an operational service provider for space-enabled inputs together with other important data layers for its use in disaster management by the central ministries and departments and the state governments in predisaster, during disaster and post-disaster phases. The DSC is also working on preparation of maps showing hazard zonation. Flood hazard zone maps for the Brahmaputra river in Assam were

prepared. Similar maps are also being prepared for Bihar. The NRSA also prepares maps in river configuration and bank erosion. It also maps flood controls works such as embankments and spurs along selected river reaches and provides this information the concerned departments.

National Centre for Medium Range Weather Forecasting (NCMRWF) – It is the premier institution in India under the Department of Science and Technology (DST) to provide medium range weather forecasts through deterministic methods.

National Flood Management Institute - The MOWR in close collaboration with the NDMA will establish a National Flood Institute (NFMI) as a centre of excellence with experts as its faculty and having state-of-the-art equipment at an appropriate location, in one of the flood prone states. The institute will be functional by the end of December 2010. Till then the NWA will undertake these activities in addition to its current functions.

State Flood Control Boards/State Flood Control Technical Advisory Committees

Flood being a state subject, FM schemes are planned and executed by the State governments. The role of the central government is advisory, catalytic and promotional in nature. The states have to investigate, plan, construct, maintain and operate all flood works. Flood Control Boards were set up in some of the states along with the CFCB.

State Flood Control Boards/State Flood Control Technical Advisory Committees

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State Disaster Response Force: To augment their capacities, all state governments/SDMAs will organise, from within their armed police force, adequate personnel for the constitution of State Disaster Response Force (SDRF) with appropriate disaster response capabilities. Under the aegis of the NDMA, the states will raise the SDRF.

Intra-state Multi Sectoral Coordination

While the state irrigation/water resources/flood control departments are responsible for planning, implementation and operation and maintenance of structural measures of FM in the state, civil authorities at the district/taluka/block/village level are responsible for search, rescue and relief. Further, the activities of one department, such as the construction of roads by the PWD, or railway lines by the Ministry of Railways (MOR), urbanisation/ industrialisation regulated by the ULBs and town and country planning organisations etc can affect the vulnerability of an area to floods and drainage congestion. The floods in the Krishna basin in 2005 are a case in point. It is therefore important that a mechanism is established for ensuring coordination among the various departments of state governments. In most of the flood prone states, State Flood Control Advisory Committees have been constituted with representatives of the various departments of the state governments and central organisations concerned, where the FM schemes proposed by the state irrigation/water resources/ flood control departments are considered and approved.

State governments/SDMAs with the cooperation of the CWC and other states will implement the IWRM system for all the river basins and sub-basins. (NDMA, 2008; Planning Commission, 2011; INDIA-WRS-NRSC, 2014)

Policies/Guidelines & Initiatives

After the unprecedented floods of 1954, the Government of India took several initiatives and constituted a number of Committees to study the problem of floods in the country. A brief account of the recommendations of some of the important expert committees are as follows.

Policy Statement - 1954

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.

In the supplementary statement placed before the Parliament on the 27th July, 1956, the above optimistic note changed a little, stating “We shall, however, be able to curb and confine the floods, more and more and do all that is possible to save ourselves from the harm and the devastation that they bring”. Simultaneously, a statement on the flood situation and flood control programme was

laid before the Parliament. In this Statement, it was, pointed out that absolute immunity from flood damage was not physically possible even in the distant future.

High Level Committee on Floods – 1957 & Policy Statement of 1958

A High Level Committee on floods submitted its report in December, 1957, and this was considered by the Central Flood Control Board in its seventh meeting held in May, 1958. Some of their important recommendations are

(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.

(iv) Effects of embankments on river regime be considered, before approving such proposals.

(v) In general, embankments are satisfactory means of flood protection when properly designed, executed and maintained, but a suitable combination of this method with other methods such as storage dams, detention basins, etc. is usually more efficient and should be adopted as resources permit.

(vi) Priorities for soil conservation work relating to flood control should be as under:-

(a) Catchment areas of multi-purpose dams.

(b) Himalayas with their foothills.

(c) Indo-Gangetic plain and

(d) Deccan plateau.

vii) Works relating to watershed management prioritized. Work commenced in a catchment should not be left incomplete to take up work in other catchments.

(viii) The following order of priority in general is recommended:-

(a) Emergent schemes,

(b) Continuing schemes,

(c) Schemes for the protection of important urban and industrial communities.

(d) Schemes which would help in augmenting flood protection in the country.

(e) Schemes which combine other beneficial utilization of waters.

Another policy statement placed in Parliament in 1958 also emphasises that while substantial diminution of flood related distress is possible, immunity against flood is impracticable.

National Flood Commission (Rashtriya Barh Ayog) – 1980.

The National Flood Commission (R.B.A.) submitted its comprehensive report in March, 1980. This contained a total of 207 recommendations covering the entire gamut of flood problem in the country. Some of the important recommendations are given below.

- 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.

- A comprehensive dynamic and flexible approach to the problem of floods as a part of a comprehensive approach for the utilization of land and water resources.

- Priority for measures to modify the susceptibility of life and property to flood damage.

- Priority for completion of continuing schemes.

- Adequate funds for maintenance.

- States to enact legislation amending section 17 (II) of land acquisition act, to make the existing provisions for emergent situations, as applicable for flood control works.

- Intensifying studies on sedimentation of reservoirs.

- Forming a national council for mitigating disaster.

Expert Committee to Review the Implementation of the Recommendations of National Flood Commission-2003 (R Rangachari Committee)

An Experts Committee under the Chairmanship of Shri R Rangachari was set up by Ministry of Water Resources, Government of India in October 2001 to review the implementation of recommendation of National Flood Commission.

The Committee suggested emphasis on 25 recommendations out of 207 and summed up its views as follows:

- 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.
- RBA has made a number of recommendations on the future approach and the planning and implementation thereof. Most of these have not been implemented or at the best partially implemented. They will have to be kept in view as part of future approach.
- The international dimensions of flood management as an integral part of Water resource development and management must be pro-actively addressed.
- A number of other issues of importance like adequate funds, legislation, research and people's involvement at all important stages, etc are very important to effectively manage floods. However, the inter-state issues in multi-state river basins is a very important matter waiting to be effectively addressed.

National Water Policy (1987/ 2002/2012)

The Government of India while framing policy has laid significant emphasis on the management of floods which gets reflected in the National Water Policy as under:

The National Water Policy (1987) adopted by the National Water Resources council, inter alia, recommended that "adequate flood cushion should be provided in water storage projects wherever

feasible to facilitate better flood management". While it recognized that "physical flood protection works like embankments and dykes will continue to be necessary", it laid emphasis on adoption of non -structural measures for the minimization of losses, such as flood forecasting and warning and flood plain zoning etc.

The National Water Policy of 2002 adopted by the National Water Resources Council inter alia recommended the following guiding principles:

(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.

(vi) The erosion of land, whether by the sea in coastal areas or by river waters inland, should be minimized by suitable cost-effective measures. The States and Union Territories should also undertake all requisite steps to ensure that indiscriminate occupation and exploitation of coastal strips of land are discouraged and that the location of economic activities in areas adjacent to the sea is regulated.

(vii) Each coastal State should prepare a comprehensive coastal land management plan, keeping in view the environmental and ecological impacts, and regulate the developmental activities accordingly.

(INDIA-WRS-NRSC, 2014)

General Flood Management Measures

The National Water Policy of 2012 adopted by the National Water Resources Council inter alia recommended the following guiding principles:

Different measures have been adopted to reduce the flood losses and protect the flood plains. Depending upon the nature work, Flood protection and flood management measures may be broadly classified as under:

(a) Engineering / Structural Measures

(b) Administrative / Non-Structural Measures

Engineering / Structural Measures

The engineering measures for flood control which bring relief to the flood prone areas by reducing flood flows and thereby the flood levels are –

(a) an artificially created reservoir behind a dam across a river

(b) a natural depression suitably improved and regulated, if necessary or

(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 bye passing a particular town/reach of the river prone to flooding.

The engineering methods of flood protection, which do not reduce the flood flow but reduce spilling, are:

(a) embankments which artificially raise the effective river bank and thereby prevent spilling and

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

Different aspects of some of the important measures for flood management are enumerated below:

Reservoirs

Reservoirs can moderate the intensity and timing of the incoming flood. They store the 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. 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 space is earmarked, as in the case of DVC dams across the Damodar and its tributaries. The operation schedule or rule curve being followed should be reviewed and a suitable operation schedule/rule curve prescribed for the monsoon filling to ensure space for flood moderation but which can be filled for conservation at a later stage when high flows end.

In order to improve the efficiency of the reservoirs and improve the operation schedules for providing either incidental or specific flood moderation effects, arrangement for inflow forecasts should be made. 10.1.2 Detention Basins 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 are relatively in expensive. 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 a few natural basins.

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. In many places, embankments may be the only feasible method of preventing inundation. Embankments are designed and constructed to afford a degree of protection against floods of a certain frequency and intensity or against the maximum recorded floods till the time of their planning only (in the absence of detailed hydrological data for longer periods) depending upon the location protected and their economic justification. 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.

Apart from the raising and strengthening works, erosion along the embankments and natural banks of the river systems has been a serious problem on which considerable expenditure has been incurred in the past. Particular mention could be made of the erosion problem of the embankment systems in Assam, Bihar, U.P, Punjab and West Bengal. The embankments, under serious attack by the major rivers and their tributaries, have to be suitably protected by spurs, pitching and other suitable anti-erosion measures. On many embankment systems like the Kosi embankment and Piprasi-Pipraghat embankment on the Gandak in Bihar, the river attack is so severe that the protection measures required to be taken are large and cannot be covered under the normal maintenance works.

A number of Committees constituted in various countries as well as in India have deliberated upon the utility of embankments as a means for flood protection. Divergent views have emerged out of these. Many NGOs have voiced serious criticism about existing embankments. One is that problems of flood can be solved by removal of all the existing embankments and the other diametrically opposite being that construction of more and more lengths of the embankments and their raising and strengthening is the only practicable medium/short term solution for the flood problems. The reason for such wide divergence in opinion is obviously due to the inadequacy of sufficient number of performance evaluation studies of existing embankments and the divergent views on their performance. As experienced, some embankments have provided positive benefits by ensuring sustained protection against floods and river spills while on the other hand, some embankments have, in certain reaches of the river, aggravated the flood problem by rising river bed levels, decreasing their carrying capacity, causing drainage congestion in the countryside and distorting the levels/gradient of the outfall points.

Construction of embankment with proper roads has been perceived as providing useful communication linkages and reliable surface network for areas that are liable to stand completely cut off during floods and thereafter. They could provide quick communication for facilitating better supervision and maintenance of the flood protection works and provide all weather

communication facilities to the adjoining habitats. As such, they are often deemed as the life line during floods.

It is also recognised that embankments are not an unmixed blessing. They have adverse effects such as interference with drainage, inability to stand erosion, etc. which should be considered before planning this measure for flood management.

As such, this method of flood management may be undertaken only after carrying out detailed hydrological and other studies regarding their favourable and adverse effects.

Channelisation of Rivers

Some of the states are proposing channelisation 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. While venturing to channelise 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 channelising.

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 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. 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.

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 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, J&K, Gujarat and Tamilnadu. 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.

Stress has to be laid on improving the existing natural drainage system in the flood plains so that what should essentially be flooding of a few days should not get prolonged for months. In this context, the importance of the system 'dhars' or 'old channels', which efficiently served the function of draining away the spillage and surface flows generated by local rains, must be recognised. The blocking of these natural drainage channels, which is normally done in the name of "reclamation for development" because of paucity of land or vested interest, must be firmly discouraged. This applies also to all natural depressions, which are targeted for reclamation.

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.

Diversion of Flood Waters

Diversion of flood waters takes 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. Important schemes under execution or under planning are the supplementary drain in Delhi, the outfall channel in Jammu and Kashmir, the Damodar in the lower reaches in West Bengal, the Thottapally Spillway diversion in Kerala, the Kolleru lake diversion into the sea in Andhra Pradesh, the Kama-Pahari drain in Rajasthan and the Hulwaa drain in Uttar Pradesh.

Watershed Management

The watershed management measures include developing and conserving the vegetative and soil covers 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.

Administrative / Non-Structural Measures

The administrative methods endeavour to mitigate the flood damages by;

(a) Facilitating timely evacuation of the people and shifting of their movable property to safer grounds by having advance warning of incoming flood i.e. flood forecasting, flood warning in case of threatened inundation

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

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 for 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.

Flood Plain Zoning

Flood-plain zoning is a concept central to flood plain management. This concept recognises the basic fact that the flood plain of a river is essentially its domain and any intrusion into or developmental activity therein must recognise the river's 'right of way'. 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 minimised, if not avoided. Unfortunately, while all generally endorse this approach in principle, scant attention is given to it in actual practice, leading to increased flood damages.The Central Water Commission (CWC) has been continuously impressing upon the states the need to take follow-up 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.

There has been passive resistance on the part of the states to follow up the various aspects of flood plain management including possible legislation.

Flood Proofing

Flood proofing measures adopted in India in the past, consisted in raising a few villages above pre-determined flood levels and connecting them to nearby roads or high lands. Under this programme, several thousand villages were raised in Uttar Pradesh in the fifties. In West Bengal and Assam also land-fills were attempted in villages to keep houses above flood levels even though nearby agricultural lands were liable to inundation. During X Plan, the Government of Bihar had also constructed, with Central assistance, the raised platforms for safety of the people in flood prone areas of North Bihar. (Planning Commission, 2011; INDIA-WRS-NRSC, 2014)

CWC National Flood Forecasting Network

The work of flood forecasting and warning in India is entrusted with the Central Water Commission (CWC). Flood Forecasting and flood warning in India was 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 878 Hydrological and Hydro-meteorological sites being operated by CWC across the country covering 20 river basins for gauge, discharge, sediment & water quality observations. The formulation of a forecast requires effective means of real time data communication network from the forecasting stations and the base stations (380 nos approx at present). Wireless Communication system installed in almost 550 stations is the backbone of the communication system required for flood forecasting activities. The activity of flood forecasting comprises of Level Forecasting and Inflow Forecasting. The level forecasts help the user agencies to decide 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 175 stations (28 Inflow Forecast Stations and 147 Level Forecast Stations). Annually, about 6000 flood forecasts are issued by CWC during floods.

In order to meet the requirement of real-time data collection, automatic data transmission and flood forecast formulation, expeditious data / information dissemination, the Central Water Commission has undertaken modernization of its data collection and flood forecast network. During IX Plan, 55 telemetry stations were installed in Mahanadi and Chambal Basins besides setting up of two Earth receiving Stations (ERS) at Jaipur (Rajasthan) and Burla (Orissa). During X Plan, modernization of 168 stations was undertaken; out of which 166 stations besides 11 Modelling Centres have been set up till date. During XI Plan, additional 222 stations and 10 Modelling Centres are proposed to be installed; which would help the concerned States in taking appropriate measures in advance for evacuation of people and shifting them and their properties to safer locations. (Planning Commission, 2011)

Table 2: Statewise Distribution of Flood Forecasting Stations in India

Sl. No.	Name of State/UT	Number of flood forecasting Stations		
		Level	Inflow	Total
1	Andhra Pradesh	9	7	**16**
2	Assam	24	0	**24**
3	Bihar	32	0	**32**
4	Chhatisgarh	1	0	**1**
5	Gujarat	6	5	**11**
6	Haryana	0	1	**1**
7	Jharkhand	1	4	**5**
8	Karnakata	1	3	**4**
9	Madhya Pradesh	2	1	**3**
10	Maharashtra	7	2	**9**
11	Orissa	11	1	**12**
12	Tripura	2	0	**2**
13	Uttar Pradesh	34	1	**35**
14	Uttarakhand	3	0	**3**
15	West Bengal	11	3	**14**
16	Dadra & Nagar Haveli	1	0	**1**
17	NCT of Delhi	2	0	**2**
	Total	**147**	**28**	**175**

Flood Management Programme

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 (a Centrally Sponsored Scheme),

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

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

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

The above schemes have been merged together and a restructured scheme, namely, "Flood Management Programme" under State Sector in Central Plan has been approved in-principle, for XI Plan period.

The scheme "Flood Management Programme" would be implemented generally by Flood Control/ Water Resources / Irrigation Departments of the State Governments. In exceptional and emergent cases, the works could be entrusted to the central government organizations / undertakings, with the approval of Union Minister for Water Resources. Managerial Inputs towards financial management, quality control, physical progress, timely completion of the works, etc. shall be the responsibility of the state governments/ implementing agencies.

Under "Flood Management Programme" scheme, critical flood control and river management works in the entire country would be covered. These works would include river management, flood control, antierosion, drainage development, anti-sea erosion, flood proofing works besides flood prone area development programme in critical regions. It would also include restoration of damaged flood control/ management works. (MOWR, 2009)

Achievements in Flood Management

In India, systematic planning for flood management commenced with the Five Year Plans, particularly with the launching of National Programme of Flood Management in 1954. During the last 48 years, different methods of flood protection structural as well as non-structural have been adopted in different states depending upon the nature of the problem and local conditions. Structural measures include storage reservoirs, flood embankments, drainage channels, anti-erosion works, channel improvement works, detention basins etc. and non-structural measures include flood forecasting, flood plain zoning, flood proofing, disaster preparedness etc.

The various flood management measures undertaken through the successive five year plans are summarized below:-

1.	Flood embankments	34397.61 km
2.	Drainage channels	51317.50 km
3.	Towns protection works	2400 Nos.
4.	Villages raised	4721 Nos.

Reservoirs constructed with exclusive flood control storage include Maithon, Panchet, Tilaiya and Konar in Damodar Valley; Chandil dam on Subarnarekha river and Rengali dam on Brahmani river. In addition, a live storage of 177 billion cubic meter created so far in the various reservoirs for irrigation, hydropower generation, drinking water etc. also help in reducing flood intensity by storing part of the flood waters in them. (MOWR, 2014)

NDMA Flood Management Guidelines 2008

Recognising the gravity of the risk and vulnerability of India to floods, the NDMA, soon after its constitution initiated a series of consultations with the various stakeholders to develop Guidelines for strengthening the existing arrangements for flood preparedness, mitigation, and post-flood emergency response, relief, rehabilitation and reconstruction. Senior representatives from the Central Ministries/ Departments and the state governments, related agencies, academics and professionals attended these meetings. The meetings acknowledged that, while several significant initiatives had been taken by government agencies in the past for addressing the risk and vulnerability of India to floods, it is necessary to undertake measures for the evolution of a holistic and integrated strategy to address the critical factors that accentuate flood risk. On the basis of these deliberations, the NDMA has prepared these Guidelines for Flood Management (FM), to assist the ministries and departments of the GOI, the state governments and other agencies in preparing Flood Management plans (FMPs).

These Guidelines rest on the following objectives aimed at increasing the efficacy of the FMPs, which will be prepared at various levels:

1. Shifting the focus to preparedness by implementing, in a time-bound manner, an optimal combination of technoeconomically viable, socially acceptable and eco-friendly structural and nonstructural measures of FM.
2. Ensuring regular monitoring of the effectiveness and sustainability of various structures and taking appropriate measures for their restoration and strengthening.
3. Continuous modernisation of flood forecasting, early warning and decision support systems.
4. Ensuring the incorporation of flood resistant features in the design and construction of new structures in the flood prone areas.

5. Drawing up time-bound plans for the flood proofing of strategic and public utility structures in flood prone areas.

6. Improving the awareness and preparedness of all stakeholders in the flood prone areas.

7. Introducing appropriate capacity development interventions for effective FM (including education, training, capacity building, research and development, and documentation.)

8. Improving the compliance regime through appropriate mechanisms.

9. Strengthening the emergency response capabilities.

(NDMA, 2008)

NDMA Urban Flood Management Guidelines

Urban flooding is significantly different from rural flooding as urbanisation leads to developed catchments which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times. Consequently, flooding occurs very quickly due to faster flow times, sometimes in a matter of minutes. There has been an increasing trend of urban flood disasters in India over the past several years whereby major cities in India have been severely affected. The most notable amongst them are Hyderabad in 2000, NDMA commenced its efforts to formulate the Flood Guidelines in 2006 and released them in 2008. NDMA has for the first time decided to address urban flooding as a separate disaster, delinking it from floods.

NDMA had proposed that MoUD should be designated as the nodal ministry for Urban Flooding. Consultations were held with MHA, MoWR/CWC, Ministry of Earth Science/ India Meteorological Department (MoES/IMD), Department of Space/ National Remote Sensing Centre (DoS/NRSC), Department of Science and Technology/ National Spatial Data Infrastructure (DST/NSDI) and SoI, MoES and MoUD and they concurred with the proposal.

MoUD has launched various programme including JNNURM, Urban Infrastructure Development Scheme for Small & Medium Towns (UIDSSMT) and North Eastern Region Urban Development Programme (NERUDP), which have a lot of relevance for management of urban flooding. The ministry is also putting in place the National Urban Information System (NUIS). They have also set up a Committee of Experts for preparation of a Stormwater Drainage Manual.

Under this Act, MoEF has issued the Municipal Solid Waste (Management & Handling) Rules, 2000. The Municipal Solid Waste (MSW) Rules provide a framework encompassing collection, transportation, treatment and disposal of municipal solid waste. As already pointed out, improper

dumping of Municipal Solid Waste (MSW) into drains/ nallahs is a major factor contributing to urban flooding.

Survey of India (SoI) under the Ministry of Science & Technology has a major role in mapping of urban areas, which will be the basic requirement for urban planning and therefore very relevant to urban flooding.

NRSC under the Ministry of Space has an important role in preparing Airborne Laser Terrain Mapping (ALTM) data and National Database for Emergency Management (NDEM). Data provided by ALTM will be very useful for geospatial urban planning. NRSC has initiated the urban flooding programme under the Indian Space Research Organisation's (ISRO) Disaster Risk Management Programme.

Management of urban flooding is the responsibility of the ULB at local level. The state government may also take various schemes/ programmes which have impact on urban flooding. However, the role of ULBs is crucial in the management of urban flooding in their respective cities/towns. (NDMA, 2010)

Transboundary-River Cooperation

Three major river systems of India namely Ganga, Brahmaputra and Indus cross international borders. The Ministry of Water Resources is responsible for strengthening international cooperation on matters relating to these rivers by way of negotiations with neighbouring countries in regard to river waters, water resources development projects and operation of international treaties relating to water.

India-Bangladesh Cooperation

An Indo-Bangladesh Joint Rivers Commission (JRC) is functioning since 1972 with a view to maintain liaison in order to ensure the most effective joint effort in maximizing the benefits from common river systems which is headed by Water Resource Ministers of both the countries. A Treaty was signed by the Prime Ministers of India and Bangladesh on 12th December 1996 for the sharing of Ganga/Ganges waters for a period of thirty years to be renewable by mutual consent. A Joint Committee has been set up for implementing, joint inspection and monitoring of the sharing arrangements at Farakka in India and at Hardinge Bridge in Bangladesh for the dry season (Jan to May) every year.

37th meeting of the Indo-Bangladesh JRC was held at New Delhi on March 17-20, 2010 wherein various matters pertaining to cooperation in Water Resources sector, including Tipaimukh Dam Project, Interlinking of Rivers, sharing aspects of waters of common rivers, bank protection works, flood forecasting etc. were discussed.

Government of India is providing necessary flood data of Ganga- Brahmaputra-Meghna basin free of cost to Bangladesh during monsoon for their flood forecasting, which has enabled them to save property and lives of their people including Military establishments.

India-Bhutan Cooperation

A scheme titled "Comprehensive Scheme for Establishment of Hydrometeorological and Flood Forecasting Network on rivers common to India and Bhutan" is in operation. The network consists of 35 hydro-meteorological/ meteorological stations located in Bhutan and being maintained by the Royal Government of Bhutan with funding from India. The data received from these stations are utilized in India by the Central Water Commission for formulating flood forecasts. A Joint Expert Team (JET) consisting of officials from the Government of India and Royal Government of Bhutan continuously review the progress and other requirements of the scheme.

India-China Cooperation

The Government of India has signed MOUs with China for provision of hydrological information of Chinese Stations on rivers Yaluzangbu/ Brahmaputra and Langquinzangbu/Sutlej during monsoon season. Both the countries have also set up an Expert Level Mechanism for addressing the issues pertaining to trans-boundary rivers.

India-Nepal Cooperation

To discuss various issues related to water resources between India and Nepal, a three tier mechanism comprising of (i) Joint Ministerial Level Commission on Water Resources (JMCWR) headed by Ministers of Water Resources of India and Nepal, (ii) Joint Committee on Water Resources (JCWR) headed by Secretaries of Water Resources and (iii) Joint Standing Technical Committee (JSTC) headed by the Chairman, Ganga Flood Control Commission, Patna from Indian side, exists.

A Treaty on Integrated Development of Mahakali (Sharda in India) river including Sharda Barrage, Tanakpur Barrage and Pancheshwar Multipurpose Project was signed between the Government of India and the Government of Nepal in February, 1996. Treaty is valid for a period of 75 years.

Pancheshwar Multipurpose Project and setting up of Pancheshwar Development Authority (PDA)

India and Nepal had signed a Treaty known as Mahakali Treaty in February'1996. Implementation of Pancheshwar Multipurpose Project is the centre piece of the Mahakali Treaty. Required field investigations for the Pancheshwar Multipurpose Project have been completed by a Joint Project Office (JPO-PI) in 2002 (except for some confirmatory tests). But mutually acceptable DPR of Pancheshwar Project could not be finalized due to differences on certain contentious issues.

During 3rd meeting of the Joint Committee on Water Resources (JCWR) held from 29.09.08 to 01-10-08 at Kathmandu (Nepal), it was decided to set up Pancheshwar Development Authority (PDA) at the earliest for the development, execution and operation of Pancheshwar Multipurpose Project. During the 5th meeting of JCWR held on, November 20-22, 2009 at Pokhara (Nepal), JCWR finalized the Terms of Reference (TOR) of PDA. Substantive issues such as sharing of cost and benefits, location of re-regulating structure, stage based implementation, etc. are, however, not finalized. It is proposed to discuss these issues now in the meeting of Indo- Nepal Joint Ministerial Level Commission on Water Resources (JMCWR).

Sapta Kosi High Dam Project and Sun Kosi Storage cum Diversion Scheme

A Joint Project Office (JPO-SKSKI) was set up in August' 2004 to undertake detailed field investigations for preparation of DPR of Sapta Kosi High Dam Project and Sun Kosi Storage cum Diversion Scheme in Nepal. The field investigations are delayed because of political instability and frequent strikes / bandhs in Nepal. The tenure of JPO-SKSKI has been extended to February, 2013 to complete field investigation and preparation of DPR.

Pancheshwar Multipurpose Project

Pancheshwar Multipurpose Project is the Central piece of Mahakali Treaty. Required field investigations for the Pancheshwar Multipurpose Project having an installed capacity of 5600 MW at Pancheshwar with irrigation and incidental flood control benefits and a re-regulating structure to primarily meet irrigation requirements downstream in Uttar Pradesh, have been completed. The Detailed Project Report (DPR) is to be finalized after mutually resolving the pending issues. It has also been decided to set up Pancheshwar Develoment Authority (PDA) at the earliest in accordance with article 10 of Mahakali Treaty.

Indo-Pakistan Co-operation

India and Pakistan signed Indus Waters Treaty in 1960, and two permanent posts of Commissioners were created, one each in India and Pakistan. Each Commissioner is representative of his Government for all matters arising out of the Treaty and is to serve as the regular channel of communication on all matters relating to implementation of the Treaty. The two Commissioners together form the Permanent Indus Commission. In fulfillment of the requirements of Indus Water Treaty, the daily data of 280 hydrological sites on six basins, The Indus, The Jhelum, The Chenab, The Ravi, The Beas and The Sutlej of Indus system was is regularly sent to Pakistan every month. Besides, Flood warnings are transmitted by India to Pakistan through Telegrams, Telephones and Radio Broadcasts during every monsoon for Indus River system.

Strategy for Bilateral Issues Related to Flood Management

- Steps may be taken for installation of automatic data collection and its transmission through satellite-based communication systems for the stations in the territories of neighbouring countries on rivers which flow into India.
- Steps may be taken for providing hourly data by China to India on Brahmaputra and Sutlej so that the same could be utilized in the flood forecasting system of India for meaningful flood forecasting in the region.
- Expedite steps for construction of large storage dams in Nepal namely Pancheshwar Multi-purpose Project, Sapta Kosi High Dam and emphasis may be given on flood control besides other benefits of irrigation and hydropower generation.
- The outstanding bilateral issues regarding mutual acceptance on the DPR of Pancheswar Multi Purpose Project may be resolved with Nepal at the earliest.

  (Planning Commission, 2011)

Institutional Reforms

The following institutional reforms are suggested for effective flood management in the country:

Expedite setting up of River Basin Authorities – The issue of setting up of River Basin Authorities has been raised by the Expert Committees long back. However, action in this regard is yet to be taken both by Central as well as State Governments. The primary action is to be taken up by the State Governments but so far no concrete action from their side has been taken for initiating

a proposal for setting up of the River Basin Authorities. Integrated water resources management including integrated flood management can be addressed with collaborative efforts of all agencies / mechanisms involved in this gigantic task. Therefore, our efforts need to be concentrated for setting up of River Basin Authorities with top managerial skills and with appropriate delegation of powers and to complete this task in a time bound manner in the interest of sustainable management of India's water resources and addressing flood problems in a holistic manner.

Strengthening of Organizations under MOWR

The Organizations, namely, Central Water Commission, GFCC and Brahmaputra Board under the Ministry of Water Resources are required to play vital roles in preparation of master plans for specific river basins and CWC plays important role at national level in coordinating the efforts made by various agencies in overall water resources management including flood management in an integrated manner.

The need for strengthening of these Organizations, in order to play advisory and coordinating roles, has been emphasized by various expert committees on flood management in the past as well as in the Committee of Secretaries meeting in 2007. The strengthening of CWC is required in a time bound manner in view of the expansion of its hydrological and flood data collection network, flood data transmission and management of floods. Therefore, it is recommended that the actions at all concerned levels for time bound strengthening of these Organizations may be expedited so that flood mitigation efforts are properly coordinated in the country. The needs of these organizations regarding infrastructural facilities and vehicles required for flood data collection, flood forecasting, flood management and related inspection, supervision and coordination, are recommended to be addressed appropriately.

Strengthening of NWA Pune

The National Water Academy (NWA) located at Pune is presently involved in providing training to the engineers / officers of the Central / State Governments. Although the coverage of the training is exhaustive as per needs of the officers involved in various facets of water resources management, efforts may be made to convert NWA, Pune into a Centre of Excellence for International training programmes on matters pertaining to flood mitigation so that up-to-date globally available know-how could be shared under such training programmes.

The NWA, Pune may also be suitably strengthened to meet the requirement of NDMA for conducting trainings on disaster risk reduction programmes.

Strengthening of State Flood Control Departments

As per Constitutional provision the subject of flood management falls within the purview of the State Governments. Therefore, project-specific planning and their implementation is to be ensured by the State Governments. However, the present structure of the State level flood control departments needs to be revamped to discharge their role as prime flood managers in the State. The specific needs of human resources and their skill development are required to be addressed suitably. However, while making such revamping proposals, proper evaluation of the available strengths and the requirements of the departments to shoulder the responsibilities of flood management would need to be made.

Dispensing with the concept of 'Plan' and 'Non-Plan'

There are nagging problems in ensuring proper maintenance of the assets created by the State Governments mainly because the assets are, as per existing financial procedures, arranged under various plan schemes. The sophisticated equipment and the works undertaken with plan funds suffer maintenance when the plan schemes are closed and their maintenance is shifted from Plan to non-Plan Heads of Expenditure. In order to overcome these bottlenecks, it may be appropriate to dispense with the concept of plan and non-plan in Government procedures and the funds to central agencies / departments may be provided by the Planning Commission / Ministry of Finance to the central / state agencies on continuation basis.

No restriction on Recruitment of new Staff

Presently, there have been restrictions on recruitment of staff under the Central agencies but the important activities like collection of hydrological data, field survey works, flood forecasting and also many other functions being performed by central agencies suffer due to shortage of staff as a result of reduction in strength due to retirement / death of the employees. Therefore, it is recommended that there should not be any restriction on new recruitment of staff required for such emergent field works.

Providing adequate Infrastructural Facilities

The central agencies performing field activities related to flood management are facing various difficulties including inadequacy of infrastructural facilities for accommodating the field staff and shortage of inspection vehicles for carrying out field job, inspection and supervision. These

nagging problems need to be addressed appropriately in order to enhance their output both in terms of quality and quantity.

Capacity Building Programmes

In order to have well planned and effective flood management measures with state of the art knowledge based inputs, it is recommended that specialized in-house and foreign training may be imparted to the officers/staff of Central/State Governments in all areas of flood management including hydrological data collection & its management, survey & investigation, planning & design, hydrological studies, preparation of techno-economically sound DPRs, flood forecasting, inundation forecasting, construction, equipment operation & maintenance, use of latest GIS based technologies in decision making, etc. The specific training programmes may be drawn by respective organisations and adequate funds for the purpose may be provided.

(Planning Commission, 2011)

MAJOR FLOOD EVENTS AFTER YEAR 2000

After year 2000, major flood events in India are mentioned in brief in the Table 3.

Table 3: Major Flood Event in India after Year 2000

S. No.	Flood	Year	State
1	Jhelum Floods	2014	Jammu and Kashmir
2	Kedarnath Floods	2013	Uttarakhand
3	Floods	2009	Andhra Pradesh, Karnataka, Orissa, Kerala, Delhi, Maharashtra
4	Kosi Floods	2008	North Bihar
5	Maharashtra Floods	2005	Maharashtra State

On account of climate change, floods have also occurred in recent years in areas that are normally not flood prone. In 2006, drought prone parts of Rajasthan experienced floods. (SAARC-IDKN, 2014)

Maharashtra Floods 2005

During the last week of July, the state of Maharashtra experienced very heavy rainfall (almost one metre on 26 July 2005). On 26th July, 2005, in the afternoon after 14.00 p.m. the Mumbai Suburban Area and the entire M.M.R. Region was struck with a heavy storm. Indian Meteorological Department (IMD), Santacruz had recorded a 944 mm. of rain for the 24 hours ended at 8.30 hours on 27th July. The Municipal Corporation of Greater Mumbai [MCGM] control room and the key officers of the MCGM started receiving phone calls reporting the heavy rain and water logging in the suburban area.

This led to severe flooding especially in the city of Mumbai. Dams are overflowing in various parts of the state leading to mass evacuation of people and inundation of agricultural land. The total volume of water released from the Koyna Dam on 9 August was 40,000 cusecs. According to government sources, the rivers of Koyna, Krishna, Mula and Mutha have been flooded, and have affected 8,100,000 people in approximately 5,700 villages spread across Pune, Sangli, Satara,

Beed, Kolhapur and Solapur districts, forcing 500,000 people to evacuate. (IFRC, 2005; UNISDR, 2006).

Government action

- The central government of India gave a support of INR 1,000 *crores* (CHF 285 million) to the state, further assistance will be offered as required.
- Cash assistance is being provided to the next of kin of those who have died and to the affected. According to government sources, so far a total of 14.8 million CHF has been disbursed.
- 10 kg of wheat, rice and 10 litres of cooking fuel are being provided to each of the affected families through a government distribution system
- Within Mumbai, the Brihanmumbai Municipal Corporation (BMC) has engaged sanitary teams in collecting garbage and cleaning drains. According to BMC, 100,000 metric tons of garbage has been collected in the last ten days within Mumbai only.
- A detailed survey on damages is being carried out by the government.
- The government is still running 401 relief camps throughout the state and approximately 213,000 people are in these camps. About 1,162 medical teams are providing services in the affected areas. A hygiene awareness campaign has been initiated by the government through mass media. (IFRC, 2005)

Much of Mumbai's drainage system collapsed and as the flood waters subsided, there was a continued risk from water-borne diseases. As of September 6, 2005, the Ministry of Home Affairs (National Disaster Management Division) reported that 3,2000 people continued to be living in 44 relief camps. This is a significant reduction from previous month when approx. 200,000 people were living in relief camps. The Maharashtra state government reports the following impacts of the disaster:

- 20,000 hectares of farmland have become waste due to topsoil being washed away
- 550,000 hectares of crops were damaged
- Over 26,000 cattle losses
- Over 350,0000 houses partially damaged and over 14,000 homes destroyed

- Damage to roads and bridges estimated at CHF 330 million (USD 266 million, EUR 214 million)

The Indian government is looking at addressing reducing long-term vulnerability of the flood-affected areas, especially Mumbai which has a population of over 20 million people. Among the recommendations being examined by the government are:

- Large number of people living in low quality housing in highly vulnerable areas particularly the bed of the Mithi River
- Replacement of the Mumbai drainage system which is more than 100 years old. A Maharashtra state government report notes that unless this is done, monsoon preparedness measures will not be effective in the face of severe flooding. (Nandy S.)

Lacunae

- There was enough scope for IMD to be more proactive in providing the periodical data at an interval of at-least every one hour in an extreme situation on 26th July. IMD has located the presence of a 15 km. cloud over Mumbai by 14.00 hrs. Implications of such an extreme meteorological phenomenon should have been immediately conveyed to the concerned authorities – overruling their earlier description of forecast as 'heavy or very heavy … '
- The most important and critical job was co-ordination between the different agencies. It was experienced that though the M.C., MCGM is formally declared as a nodal controlling officer, his authority for directing action in case of a disasters in reality subjected to a lot of limitation, due to different high level authorities & agencies operating in the city independently, such as Police, Railways, Airport Authorities, Defense Authorities, Port Trust Authorities, Slum Rehabilitation Authorities, MHADA, MMRDA,. Their specific dealing with "Mumbai" do not appear to be clear as to from whom they should expect and receive orders for actions to be taken under the disaster management situation. These agencies in reality are not properly linked with the system of procedures and flow orders and directives from the Disaster Management Controlling Agency for Mumbai.
- The public communication net-work such as M.T.N.L. Telephone and the cellular phones did not come out under the situation on 26th & 27th July as an assured dependable

communication mechanism. The cellular network of all the service providers was down and M.T.N.L. telephones also were partially functioning.

- Mumbai's local trains on the Western, Central & Harbour tracks carry more than 40 lakhs passenger a day. The system came to a grinding halt. As per the present design of the railway system, when the water level rises (10 cms.) & above on the railway tracks, the local train services are suspended.
- the main stations and sub-stations on the power distribution net-work got submerged which had a domino effect of affecting the communication network, operation of pumping stations of water supply, storm water and sewerage and many other systems which are power dependent in today's technological society.
- No contingency planning of the Government offices as well as commercial, industrial and educational establishments appears to be available for an emergency situation. No road corridors or special tracks were kept open for the 'Relief and Rescue vehicles.'

(UNISDR, 2006)

Kosi Floods 2008 – North Bihar

On 18 August 2008, the Kosi River burst through its eastern embankment about 13 km upstream of the Kosi Barrage in Nepal, 8 km north of the Indian border. At its peak, the intensity of water force went up to 166,000 cubic feet per second (cusec) compared with the regular 25,744 cusec, running straight down south through a new course 15-20 km wide and 150 long north to south. This created major flooding in Nepal and India - Bihar in particular. According to official sources, a total of 3.3 million people were affected in Bihar alone.

The districts of Supaul, Saharsa, Madhepura, Araria and Purnia in Bihar were severely affected by the flood. A total area of close to 3700 sq. km, 30 percent of the affected areas districts, was inundated, affecting 412 Panchayats and 993 villages. Approximately 493 lives were lost and 3,500 were reported missing after the disaster.

The Government of Bihar (GoB) was extremely proactive in relief operations in the immediate aftermath of the flood. An emergency response effort was initiated by the State government with assistance from the Indian Army, Air Force, Navy, National Disaster Response Force (NDRF), as well as a number of international and national relief organizations. An extensive evacuation

operation was undertaken to bring approximately 1 million evacuees to safety. The State Government set up 360 relief camps within school and college buildings and tents to house evacuees. At peak, more than 440,000 people were living in camps.

The floods impacted already vulnerable communities with low human and economic development indicators and relatively low coping capacities. Bihar‟s poverty rate is 42 percent compared with India‟s average of 28 percent. Rural poverty in Bihar was 45 percent in 2004, the second highest after Orissa. 1

The population in Bihar is perennially affected by floods - 30 of its 38 districts (73 percent of its geographical area) are flood-prone and afflicted by floods almost annually, especially from the rivers west of the Kosi. The state is the most flood-prone in the country. Bihar‟s hydrological vulnerability is aggravated by its flat topography, high rainfall (more than 2,500 mm annually and up to 80 percent of annual precipitation from June to September) and high sediment loads of rivers. The Government of Bihar‟s institutional capacity to manage the disaster was particularly challenged with the preceding large-scale flood of 2007 followed by the Kosi floods of 2008. Furthermore, the affected districts were not exposed to inundation from the Kosi River since it‟s embankment in 1963. The population, as well as local and state government structures, was not fully prepared for such a level of disaster. Hence, recovery from these two consecutive „unprecedented‟ disasters has stretched public infrastructure, public services, and fiscal resources beyond limits. (GFDRR, 2010; UNDP, 2009)

Damage Overview

Housing: According to GoB figures, 236,632 houses were fully or partially destroyed across the districts of Supaul, Madhepura, Saharsa, Araria, and Purnea. The estimated damage is Rs. 5,935 million (US$ 134.9 million). Of these, the first three districts were the worst hit with over 95 percent of the reported damage.

Roads and Bridges: About 1800 kilometers of paved and unpaved roads and about 1100 bridges and culverts were destroyed in the floods. Maximum damages were reported in Supaul, Madhepura and Saharsa.

Water Resources (Irrigation and Flood Protection): Extensive structural damage was caused to irrigation and flood protection infrastructure, including the Kosi barrage. More than 6 km of the main Eastern Kosi Canal was fully damaged, 3 km of the branch, and 1 km partially damaged.

Over 150 km of the distributaries and sub-distributaries were fully damaged, as well as 730 km of the water courses, 151 canal bridges, and 138 regulators.

Agriculture and Livestock: Over 350,000 acres of paddy, 18,000 acres of maize and 240,000 of other crops were adversely affected, impacting close to 500,000 farmers. Approximately 10,000 milk animals, 3000 draught animals, and 2500 small ruminants perished in the disaster In addition to these sectors, major damages were caused to the livelihoods, health, education, social, and environment sectors. Over 90 percent of the flood affected population was dependent on agricultural livelihoods which were severely affected. Educational infrastructure and scholastic calendars were affected in all five districts, and regular curative and preventative health services disrupted. In addition, 273,000 acres of arable land has been rendered fallow due to sand-casting with long-term implications for the environment, agriculture, and livelihoods. (GFDRR, 2010)

An emergency response effort was immediately initiated by the State government with assistance from the Indian Army, Air Force, Navy, and National Disaster Response Force (NDRF). Relief materials were airdropped by helicopter including 121,892 packets containing food and water purification tablets. Food packets totaling 239,858 were also distributed in the interior areas by boats.

Andhra Pradesh, Karnataka, Orissa, Kerala, Delhi, Maharashtra Floods 2009

The **2009 India floods** affected various states of India in July 2009, killing at least 36 people in Orissa and 13 in Kerala. The most affected states were Karnataka, Orissa, Kerala, Gujarat and North-East Indian states.

Floods triggered by heavy monsoon rains killed at least 36 people in the eastern Indian state of Orissa alone and inundated half a million homes. On 13 July, seven people were killed and many others missing when a bus fell into a rivulet after being swept away by flood waters in Nayagarh district in Orissa. Nayagarh is 87 km from the Orissa state capital, Bhubaneswar. The world famous Sun Temple at Konark is also water-logged, causing hardship for tourists. The most flood affected districts in Orissa are Nayagarh, Cuttack, Ganjam, Keonjhar, Koraput and Kandhamal.

Several parts of Kerala were affected with the torrential rains with losses amounting to crores of rupees. At least 13 people in Kerala state are reported dead due to floods in the state.[11] The most affected districts of Kerala are Kannur, Ernakulam,

Kozhikode, Kollam, Thrissur, Malappuram, Wayanad, Kasaragod and Alappuzha districts. A number of relief camps are opened throughout the state. The Revenue Minister of Kerala state, K. P. Rajendran at Kozhikode has convened a meeting on 20 July 2009 to review the damage caused by rain. District Collectors and officials of the various departments of Kasaragod, Kannur, Wayanad, Kozhikode, Malappuram and Palakkad districts are likely attend the meeting.Over three lakh people have been hit after incessant rains in Assam and other north eastern states of India. At least 10 people, including four children and two women, were killed and nine others injured on 27 July 2009 when a wall collapsed due to heavy rains in the satellite township Noida of the national capital of Delhi.

State	No of deaths reported
Orissa	36
Kerala	13
Delhi	10
Karnataka	178
Andhra	37
Maharashtra	25

(Wikipedia, 2014)

Kedarnath, Uttarakhand Floods 2013

During 15–17 June 2013, incessant rainfall centred at Uttarakhand, caused devastating floods and landslides in the country's worst natural disaster since the 2004 tsunami. Experts say that it is another alarm regarding the impact of rapid climate change on the environment. Unprecedented destruction by the rainfall witnessed in Uttarakhand was attributed to a unique meteorological event by environmentalists due to unscientific developmental activities undertaken in recent decades contributing to loss of lives and property. The satellite imageries show that massive landslides occurred in the upstream northeast region of the Kedarnath valley due to high intensity rainfall. Unprecedented rainfall between 10 and 18 June 2013 in the Alaknanda and Bhagirathi catchments was the main cause of the disaster in Uttarakhand. Mandakini River which is a tributary

of the Alaknanda generally receives normal rainfall during June. Average June rainfall at Kedarnath during 2007–2012 was less than 200 mm . According to the India Meteorological Department, cumulative rainfall during 14–18 June 2013 at Tehri, Uttarkasi, Tharali and Jakoli was 381, 359, 326 and 390 mm respectively. Remote sensing satellite images of 28 May and 21 June 2013 show that there was approximately 30% increase in snow cover in the Alaknanda/Mandakini catchment area. It is a rare phenomenon to have snowfall of this extent during June. (Rao K.H.V. Durga et.al, 2014)

From all accounts it is clear that areas around all four Pilgrimage centres (Gangotri, Yamunotri, Kedarnath and Badrinath) and the fifth one of Hemkunt Sahib faced severe rainfall and floods during 15-18 June 2013.In addition, areas of Pithoragarh (Goriganga basin), Himachal Pradesh (Kinnaur district, mainly Kashang area, a tributary of Sutlej) basin and adjointing parts of Nepal also faced flood disaster during the same period. The flash floods in June 2013, affected 12 out of the 13 districts in Uttarakhand. The 4 districts that were worst affected were Rudraprayag, Chamoli, Uttarkashi and Pithoragarh. (SANDRP, 2013; ReliefWeb, 2013)

According to National Remote Sensing Centre, ISRO, a whopping 1356 landslides have taken place in only the Alaknnanda basin. "In the preliminary assessment, a total of 1356 landslides have been identified along the river valleys of Mandakini, Mandani, Kali, Madhyamaheshwar and parts of Alaknanda from Srinagar to Chamoli. Some of the towns included in this area are Kedarnath, Sonprayag, Gaurikund, Okhimath, Guptkashi, Mansuna, Phata, Agastmuni, Rudraprayag, Srinagar, Gauchar, Karnaprayag, Nandprayag, Chamoli etc." (SANDRP, 2013)

Figure 4: Indian map showing fusion of Westerlies and monsoon clouds in June 2013; Source: NIDM, 2013

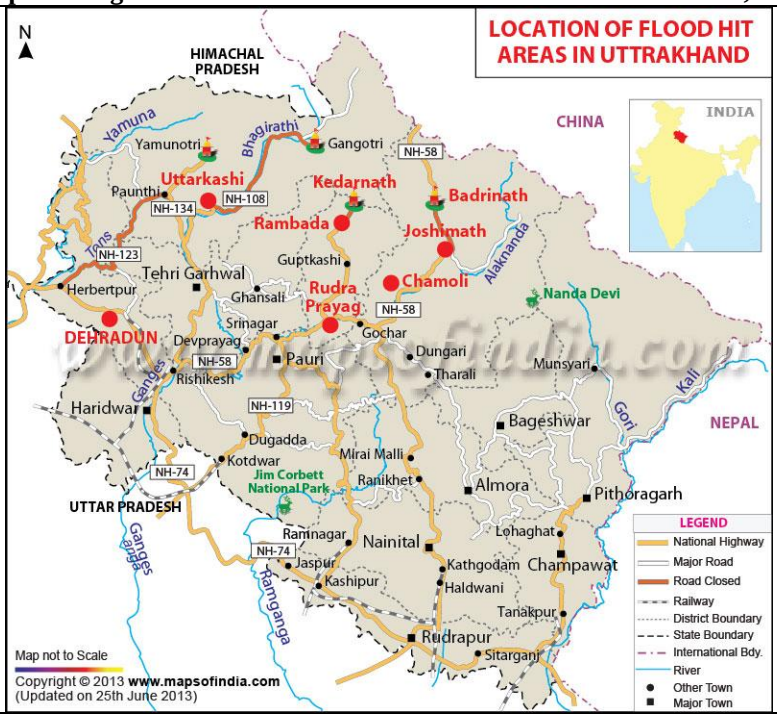

Figure 5: Location of Flood Hit Areas in Uttarakhand; Source: Maps of India

The before and after pictures below are self-explanatory. The post-flood image on Bhuvan (ISRO'a geoportal) was acquired on 21 June, 2013. Zooming into the Kedar valley area highlights the disturbances and flooding that have occurred north of the region, including the emergence of a new stream (number 3 in the image) which has cut across a green patch. The water brought down a lot of debris towards Kedarnath and further down into the Mandakini river, causing the major disaster. This is an initial assessment; other parameters such as rainfall data and terrain will need to be examined for further analysis. (Varshnay V., 2013)

Figure 5: Before and After Flood Satellite Images of Kedarnath Area in Uttarakhand; Source: Bhuvan (Indian Space Research Organization's Portal)

Figure 6: A view of Flooded River in Uttarakhand; Source: SANDRP, 2013

Some other Satellite images and GIS computed maps help to understand this situation:

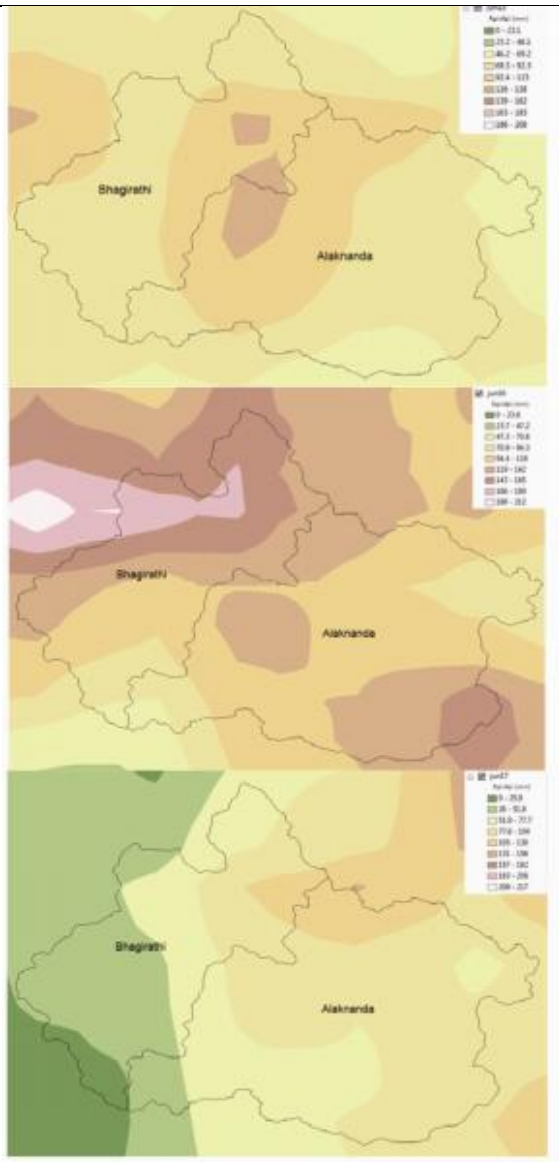

Figure 7: Spatial variation of rainfall in Bhagirathi and Alaknanda catchments as intercepted by TRMM on 15, 16 and 17 June 2013 (in mm); Source: Rao K.H.V. Durga et.al, 2014

Figure 8: Resourcesat-2 L4-MX data of 21-June-2013 showing flood affected area in part of Uttarakhand (Kedarnath Area); Source: NRSC

The website of National Remote Sensing Centre has uploaded some relevant satellite images too. The first image (Resourcesat-2 AWiFS Image of June 1, 2013) i.e. Figure 9A, of the area acquired on June 1, 2013 shows some snow covered areas in the upper reaches of Himalaya. This was well before the rains hit. The second image (Resourcesat-2 AWiFS Image: June 21, 2013) dated June 21, i.e. Figure 9B, which was acquired after the event, clearly shows that the area under snow has

increased substantially. This suggests that there would have been heavy rainfall in lower areas, including the Kedar valley and other part of Uttarakhand, leading to the floods. (Varshnay V., 2013)

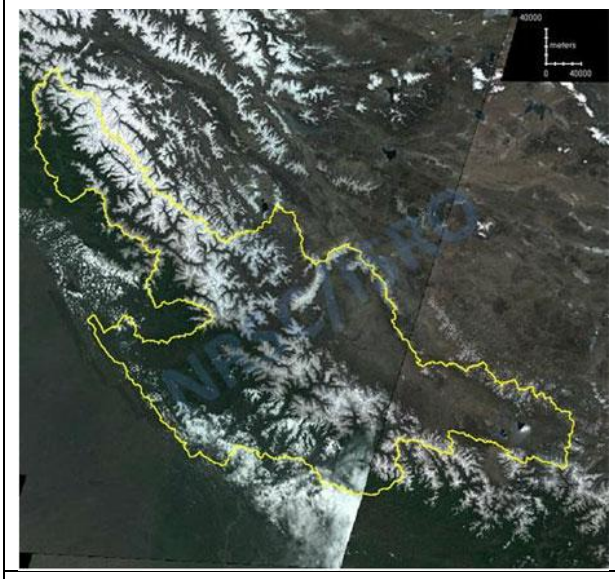

Figure 9A: June 1, 2013

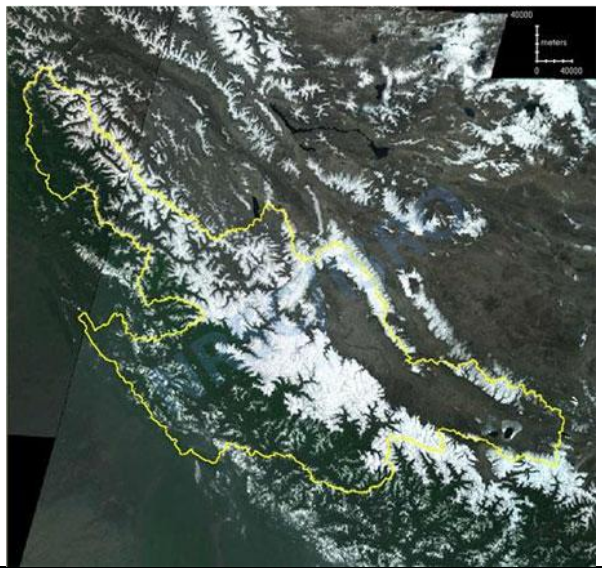

Figure 9B: June 21, 2013

Army, ITBP, NDRF, BRO, State Government and many others were involved in the post disaster rescue & search operations. Ministry of Health, Ministry of Petroleum, Ministry of Food, Corporate Sectors, NGOs, and many others played key role in rescue operation. It is one of the largest rescue operation carried out under most difficult terrain and weather condition and lack of connectivity. About 1,60,000 people were rescued safely without any major injuries. 1,10,000 people has been shifted to safer site.(NIDM, 2013; SphereIndia, 2013)

Lacunae

- Lacuna in early warning/ monitoring, information sharing, etc. and what went wrong and what can be learned from this. Mountains are fragile and every year new roads and infrastructures are developing and they are getting damaged. It is the time to relook into the existing design/maintenance approaches which may have become obsolete.
- Data/information/warnings produced by these agencies need to be customized to the level of administrators and common man, who are living in the hazardous area. Else, "heavy rainfall warning" like message of 14th June 2013 by IMD would go again into deaf ears.

CWC is yet to develop and implement such systems for major part of the country, specially areas where flash flood are frequent. Virtual simulations of flood scenarios are developed in other countries like Japan, but we are yet to advance in these areas. Landslides are primarily happening due to human interventions. Effective warning systems involving community and bio-engineering measures need to be opted.

- Issues of coordination among various departments during the Uttarakhand disaster and role of unified command system in disaster management.
- The encroachment near and around Kedarnath Temple in the valley. (NIDM, 2013)

Jammu and Kashmir Valley Floods 2014

Heavy monsoon rains began on September 2, 2014 in Jammu and Kashmir region leading to heavy flooding. The Jammu and Kashmir government sounded a flood alert for the state on September 4 after three days of incessant rain had flooded 23 villages. By September 6 the flooding was recognized as the worst in 50 years and the death toll had risen to 150.

Heavy rainfall has caused 1) flash flooding with localized damage across the state, 2) landslides, which impacted on communities and road connectivity and 3) widespread flooding in the Kashmir Valley. Flood waters breached embankments in many low-lying areas in Kashmir, including the capital Srinagar, forcing people to move to safer places. The Jhelum River, Chenab and many other streams have been flowing above danger mark. The discharge rate in the river was recorded as 70000 m^3/s against the normal discharge of 25000 m^3/s. The worst affected districts are Srinagar, Anantnag, Baramulla, Pulwama, Ganderbal, Kulgam, Budgam, Rajouri, Poonch and Reasi. The flood waters from major rivers and streams have damaged many buildings, including hospitals, and snapped road and communication links, cutting off many areas. The Army cantonment, Civil Secretariat and the High Court in Srinagar have been inundated. Transmission at Radio Kashmir Srinagar has also stopped. Communication system has been disrupted. While the situation eased a little in Jammu, large areas in Kashmir are still inundated. (SphereIndia, 2014; ReliefWeb,2014; Wikipedia-J&KFloods2014)

NDMA sought the assistance of corporate sector for tents, blankets and medicines (NDMA-PressRelease, 2014)

About 1.1 million people were affected in terms of communication, accessibility, availability of supplies, agriculture, livestock etc. (SphereIndia, 2014)

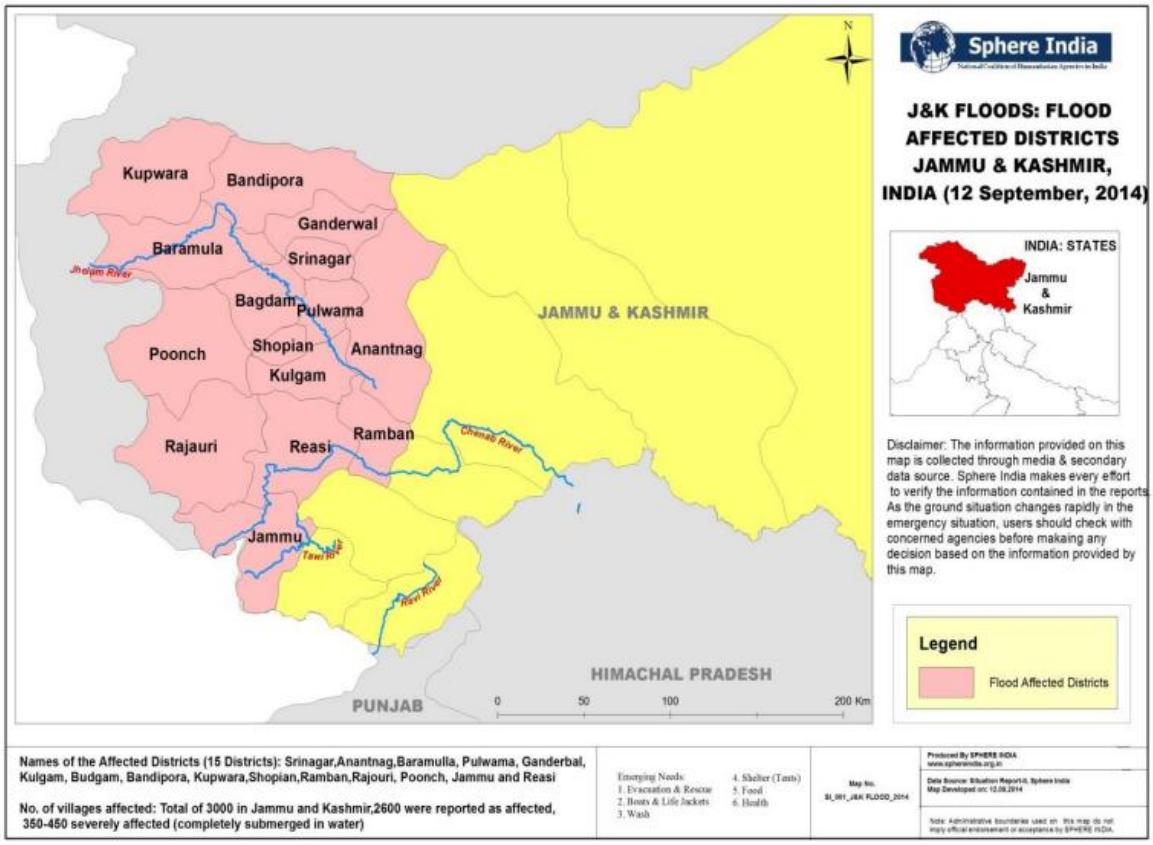

Figure 10: J & K Floods Affected Districts; Source: SphereIndia

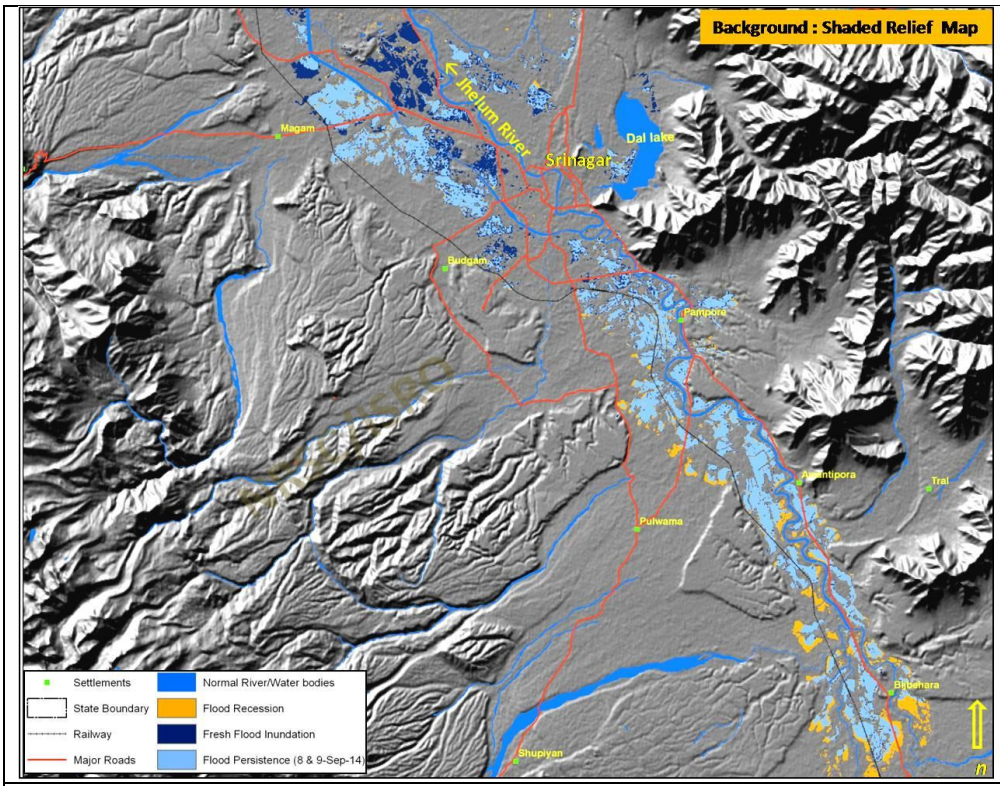

Figure 11: Flood Progression and Recession during 08-09 September 2014; Source: NRSC / ISRO

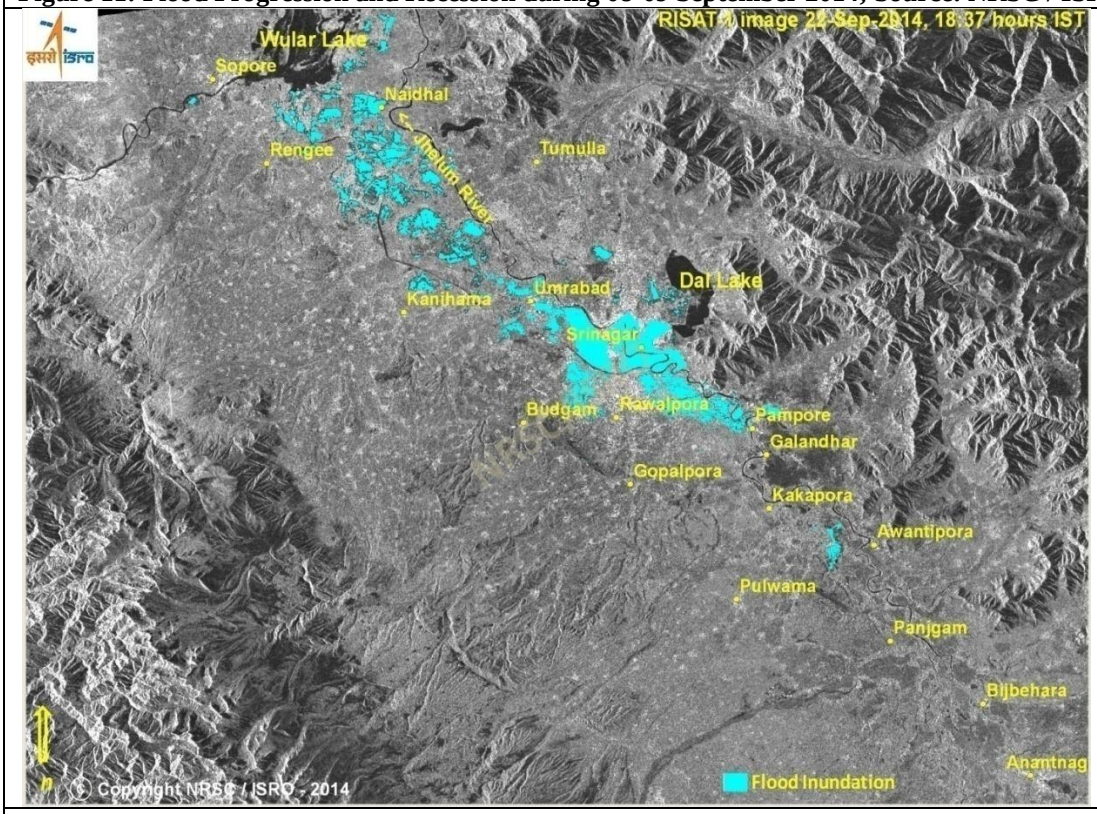

Figure 12: Satellite Image of Flood Inundated areas on September 22, 2014; Source: NRSC

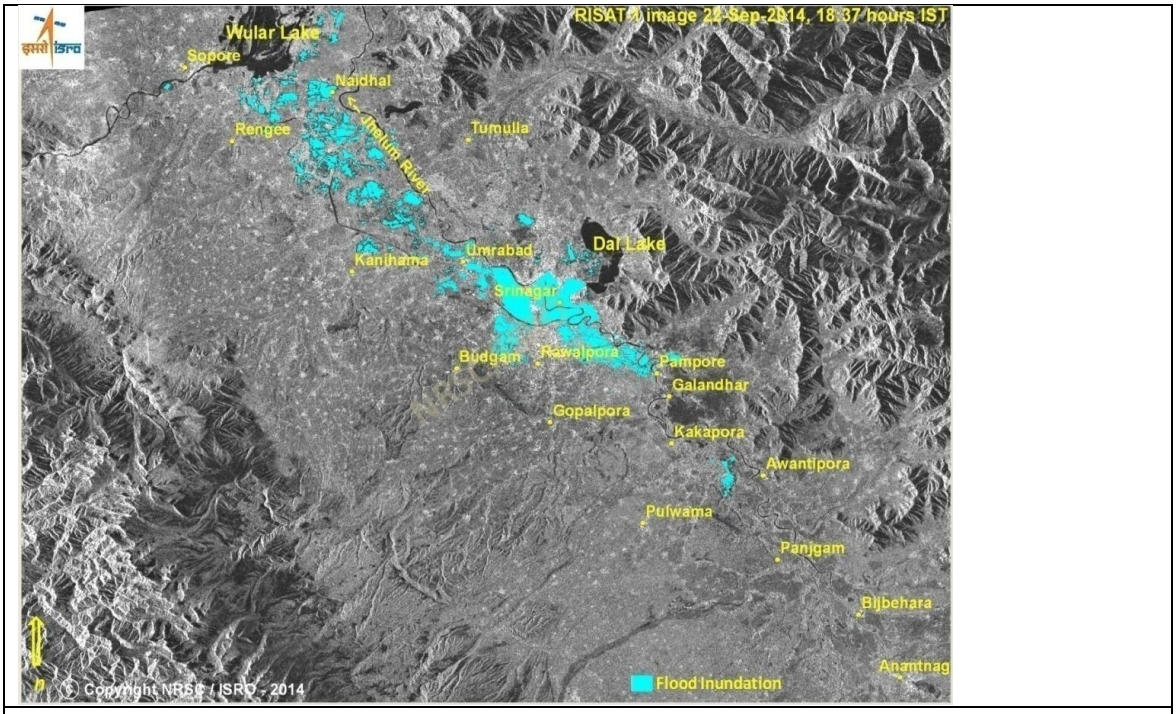

Figure 13: Satellite Image of Flood Inundated areas on September 22, 2014; Source: NRSC

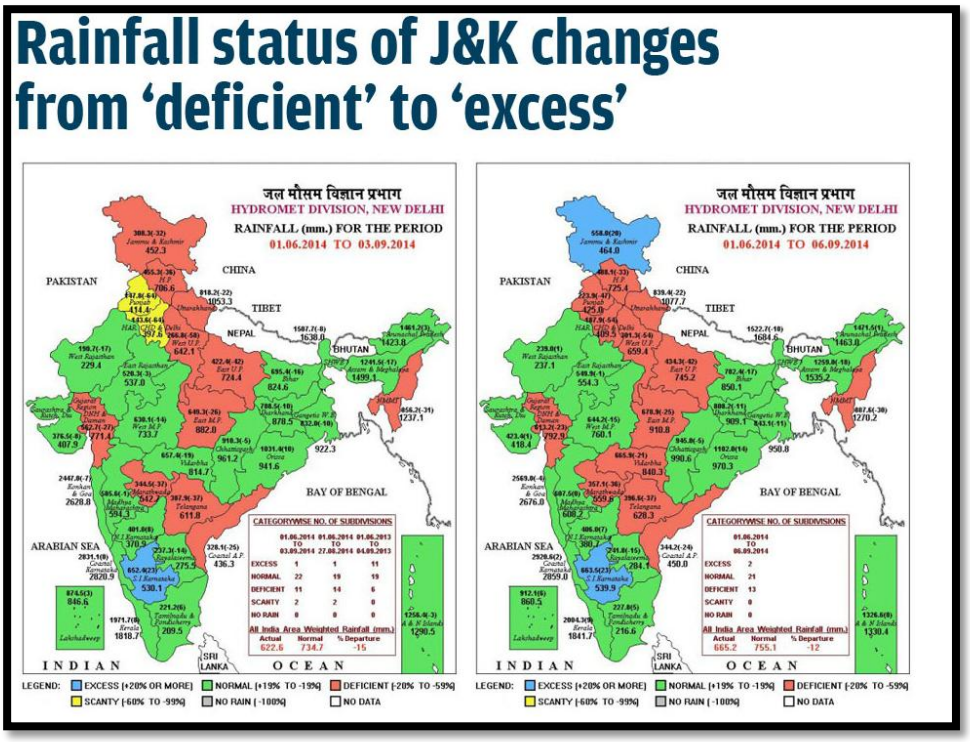

Figure 14: Jammu and Kashmir Rainfall status change between 1st June 2014- 3rd September 2014 and 1st June 2014-6th September 2014. Source: Indian Meteorology Department

Lacunae

The state government had approved a three-tier Disaster Management Policy in February 2012 to put in place a proper mechanism for rescue, relief and rehabilitation of disaster victims. But, according to sources, the state government could not create a separate department which would only deal with disasters. (Basu S., 2014)

According to V D Roy, director of flood forecasting, Central Water Commission, the state has a hydrological observatory which shares data with the state government, but it does not have a flood forecasting network. Roy says that till date CWC has established 175 stations for flood forecasting, but none of them are in Jammu and Kashmir. (Basu S., 2014)

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