

THEMATIC SESSION B2: FLOOD

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ABSTRACTS

REAL TIME FLOOD WARNING -AN EXPERIENCE

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In this paper the author recounts his own experience of real time flood warning and its salutary effect when on 5.10.1968 the river Kosi was visited by the highest flood of 25,900 cumec ever recorded. As most of the senior officers at Headquarter were on Puja vacation the author, then an E.E. in CE's office at Patna, took over the reins of handling the grave situation. The task ahead was to evacuate the villagers marooned in more than 308 villages lying within the Kosi embankments and protect the embankment. At that time there was no flood forecasting arrangements as existing today. Real time flood levels used to be transmitted from Project G-D sites at Barakhhetra and Bhimnagar to Patna Hq. by wireless system for transmission to all concerned.

As soon the author received the message of menacingly rising rate of W.L. and discharge at Barakhshetra on 3.10.68 following steps were taken by him.

- i) G.D. data from Barakhshetra and Bhimnagar were obtained, every half an hours which were used by the author to calculate expected time and anticipated rise in W.L. at different points all along the embankment.

ii) The data so calculated were immediately transmitted to concerned civil authorities by police wireless which enabled them to inform villagers well in advance and to take appropriate measures to get them evacuated wherever needed.

iii) The A.I.R. Patna was also mobilized to announce every half hour the likely rise in W.L. at different places and warning villagers to rush out quickly.

The above measures worked wonders and most of the maroon villagers could be evacuated well in time. No loss of human life reported. The barrage and embankments too remained safe. This experience outlines the importance of timely warning and benefits of flood forecasting.

COMMUNITY PARTICIPATION IN FLOOD MANAGEMENT

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It is no denying that community participation and self--reliance is necessary to strengthen the efforts of disaster preparedness. Community participation in flood management is possible in following areas.

i) Construction of Ponds: Community participation can be promoted in construction of ponds in each flood-prone village which would not only provide surface detention of flood water but will also bring economic benefits through pisciculture and aqua-culture which are more profitable than farm produce. The Community will reap other benefits too like irrigation, recharge of G. W. etc. from ponds.

ii) Construction of Raised Platforms: Raised Platforms stand out as the cheapest mode of Flood Proofing measures and can widely attract community participation through Panchayat and N.G.O. Govt. support will make it more lucrative. Every flood-prone village should be encouraged to provide 'land and construct Raised Platforms for their own shelter and relief~ during floods and for Panchayat activities during non-monsoon. The earth required for making Raised Platforms can be had by digging ponds in the vicinity. This will provide twin advantage of flood mitigation through ponds on one hand and shelter during floods on the other hand.

iii) Sinking of Injection Tube well: Floods can also be mitigated by absorption of flood water into G. W. through process of infiltration either by a) Basin method or b) by Injection well method. Simply raising of farm ridge height by 15-20 cm can help in retention and absorption of flood

water to a sufficient extent. So will be through Injection Tube well. NGO's and community participation in this sphere will be most fruitful.

iv) Formation of Anti-Flood Brigade: Villagers can form such brigades to give any information on likely danger to embankments or villages for prompt action. Such Village Brigades can even be trained in flood fighting measures with locally available materials like tree or bamboo etc. to initiate first hand measures.

**FLOOD WARNING SYSTEM OF IRRIGATION AND
WATERWAYS DEPARTMENT**

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The State of West Bengal is crisscrossed with an extensive network of rivers, their innumerable tributaries, and is beset with large numbers of low lying pockets and swamps. Diverse physical and topographical characteristics, climatologically variations, spatial and temporal variations of rainfall make 42.54% of the geographical area of the state flood prone. In addition to structural measures of combating flood, efforts have also been made by the state to combat flood non-structurally by giving flood related information to the people prior to occurrence of flood.

Web Enabled Flood Warning System: An I.T. enabled web based flood warning system was developed in 2002 through which - the Irrigation & Waterways department of the state started disseminating daily river gauge, rainfall, reservoir releases, daily flood bulletin and information regarding inundation both in textual and map form. This helped in informing people prior to the occurrence of flood through utilization of the time lag between water passing through the gauge site / barrage and actually causing flood down stream.

Limitation of the existing system: The Existing system allows only manual entry of data typically once a day contrary to hourly frequency of data collection during emergency and there is a time lag of few hours between collection and dissemination of data.

The New System: The system has since been upgraded to a real time one with the use of mobile technology which has been jointly developed with Jadavpur University and all the limitations of the existing system have been done away with.

Future system: A mathematical 3D flood simulation model is under development which will help in simulating various flood situations and thereby remedial structural measures can be adopted. This final development will help in combating flood both structurally and non-structurally.

FLOOD PROCESSES IN SMALL-SCALE DRAINAGE BASINS

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We use the island of Jamaica as an example to show that destructive flooding in small-scale drainage basins is generally dominated by sediment flows. High risk locations are relatively flat debris fans formed by accumulation of landslide debris at the mouth of water courses. These sites are increasingly being used for housing development.

Sediments sources include storm-induced landslides, loose sediment on slopes derived from old slope failures, and sediment available in the water courses. Plentiful sediment supply is maintained by debris flows that have occurred in the past and are likely to continue into the future. Rainfall thresholds that may mobilize sediment-water floods need not be associated with hurricane rainfall. It is not uncommon to observe the entire spectrum of flow behaviors in a single channel including stream flow- hypo-concentrated flow-debris flow. In a majority of cases it is the sediment deposition rather than water that is the cause of destruction.

It appears that sediment flows are generally recorded and treated as water floods and most mitigation is designed to contain water floods. This is unfortunate because mitigation strategies for sediment flows are significantly different than those for water floods.

KOSI – A REVIEW OF FLOOD GENESIS AND ATTEMPTS TO SOLVE THIS PROBLEM

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Kosi, known as River of Sorrow in Bihar, is one of the largest river of India, entering into India from Nepal. It has a notorious tendency of shifting its course due to heavy charge of silt/sediment. Kosi River has historically shifted from east to west over 114 km from 1739 to 1950 (CWC, 1981) at an implied average rate of 0.54 km per year. The river thus forms numerous Dhars, with the result built-up property and valued vegetations etc are destroyed which finally causes immense suffering and instability of life. As per one report, about 8000 sq. km. of lands in Nepal & India had been laid waste as a result of this shifting. This paper has attempted to present the genesis of recurring problem of floods in river Kosi, its eroding and oscillatory characteristics by making a review of various publications, books, reports and suggest some tangible solution to this perennial problem.

In the past, various solutions towards managing Kosi floods have been attempted since 1935 Patna Flood Conference culminating in 1953 CWPC proposal of constructing a Barrage along with Flood Embankments. The Central focus of all these conferences and proposals has been towards adopting structural measures for containing Kosi floods. Resultant structures as Hanumannagar Barrage & embankments built a few decades ago on river Kosi on Indo-Nepal border have definitely helped to temporarily check the lateral shifting of the Kosi and putting the river into a definite channel. But, this isolated engineering approach has proved to be

far too insufficient in its objectives as at present the pond of the barrage at Hanumannagar is almost full of sediments. Soon the embankments would be ineffective to control the Kosi floods. It would thus be naïve to embark upon finding a solution of this menace through structural measures alone in the form of High Dam without understanding the characteristics of floods in general and Kosi River in particular.

The paper attempts to remind the practicing engineers to adopt a multi-pronged strategy for tackling Kosi flood. This would inter-alia include construction of Kosi High Dam in Nepal as immediate solution. At the same time and in order to find a long term solution to this problem, the planners should allow the river Kosi to flow in a manner, condition, size and pattern which would minimize, if not totally eliminate, the eroding characteristics and oscillating trend of the channel/river. This may require patience and perseverance by carrying out diligent studies for understanding the texture, structure and behavior of the river over a number of years. Such efforts will also require mutually inclusive bilateral understanding between both India and Nepal.

FLOODS AND FLASH FLOODS IN HIMACHAL PRADESH: A GEOGRAPHICAL ANALYSIS

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The occurrence of water related natural disasters especially floods and flash floods are common in most of the hilly states including Himachal Pradesh. A flood can be defined as an excess flowing or overflowing of water, especially over land which is not normally submerged. The flow is markedly higher than the usual and this also cause inundation of lowland. The flood can be of various origins, but in a hilly area like Himachal they are the result of some typical reasons. They include cloudburst in the catchment's region, intense and prolonged rainfall, the downstream blocking of river channels by landslides or avalanches or the sudden breach or burst of artificial /natural lakes. In Himachal, the riverine flooding is mostly associated with the rivers having snow fed origin because in summer the snowmelt coupled with heavy rain often triggers a flood. The river Satluj and river Beas, which are being flooded almost every year, are of this type. Another form of flooding in this hilly state is flash flooding which is principally associated with hydrologically small regions. The duration of this phenomenon is short but can cause extensive damage.

The state of Himachal Pradesh has experienced a large number of incidences of floods since its inception in 1971. Though the state has also faced severe flood disasters in 1975 and 1988 but the last decade (1997-2005) has proved one of the worst decades as both the magnitude and frequency of floods have gone up. There were several incidences of floods/flashfloods during 1997-2005 and of which about five were really

gigantic. These disastrous events have brought heavy toll to the state as the loss was estimated in several thousand millions of rupees and also killed several hundreds of people besides large number of cattle heads.

The present paper is based on the primary as well as secondary data and aims at giving an account of various incidences of floods and their multi-facet impacts on the state. The paper also tries to analyze the spatial similarities and differences in the flood prone areas to find out the policy imperatives for the sustainable development.

**A REAL-TIME URBAN RAINFALL MONITORING AND FLOOD
WARNING AND DISASTER MANAGEMENT SYSTEM FOR
MUMBAI, INDIA**

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Mumbai city having an area of 437 sq km with a population of 12 million came to a complete halt due to the unprecedented rainfall of 994 mm during the 24 hours starting 0830 on 26 July 2005. At least 419 people (and 16,000 cattle) were killed due to the ensuing flash floods and landslides in Mumbai municipal area, and another 216 due to flood related illnesses. Over 100,000 residential and commercial establishments and 30,000 vehicles were damaged. Following this incident, weather stations comprising state-of-the-art tipping bucket rain gauges have been installed at 26 locations in the Municipal limits by the Municipal Corporation of Greater Mumbai. These rain gauges can be programmed to give rainfall intensity in real time (say every 15 minutes) to the emergency control room at BMC.

This paper describes the installation, operation and experiences of the system of weather stations for urban flood warning and disaster management during the monsoon of 2006. The Mumbai experience would be helpful for planning response strategies for other large cities to cope with similar events in the future.

**OBSERVATIONAL, CLIMATOLOGICAL AND FORECASTING
ASPECTS OF THE UNPRECEDENTED RAINSTORM THAT
CAUSED 26th JULY DELUGE IN MUMBAI IN 2005**

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Parts of Mumbai experienced unprecedented rainstorm on 26th – 27th July 2005 with some of its stations reported rainfall of more than 100 cm. Mumbai was totally cut off from the remaining parts of the world for almost a week. Mumbai airport was completely closed for 2 days on 26th – 27th July. Train services to and from Mumbai were also cancelled for more than a week. The initial damage assessment due to the deluge at Mumbai and flooding in the State has claimed above 1000 lives, with Mumbai alone accounting for over 409 and around 5000 crores estimated loss in the state with Mumbai accounting for about half of that. In the present paper, we, have brought out briefly the observational characteristics rainfall and circulation pattern at both large scale and meso-scale with time range from few days before the occurrence of the present event till its end by analyzing conventional surface and upper air meteorological data available from IMD and NCEP (USA) for Mumbai, Maharashtra and Indian regions corresponding to meso-scale synoptic scale and large scale respectively.

Various instability parameters along with CAPE are also computed to understand the convective characteristics of the event. We have also referred to Satellite and Radar pictures, OLR grid point spatial values and the highest reflective area maps including their heights for identification and to show cloud development characteristics corresponding to spatial rainfall data. Through the present radar data validation, a new area of third rainfall maxima is also identified spatially which was absent in surface rainfall data for Mumbai before. These findings will have tremendous

application in future if one wishes to simulate this important unique event by further sophisticated NWP model. Attempts have been made to compile complete climatologically information pertaining to different meteorological features discussed in the present study and compare them in order to understand major differences and to find the abnormalities, if any, that had happened in association with the present event. Record of other severe rainstorms which occurred over India and other parts of the world have also been looked into to determine its rank. Finally, technology available at both national/ international levels on such events is also briefly touched upon.

FLOOD MITIGATION BY RECHARGING GROUND WATER

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Mitigation of flood problem through layered storage is a concept suggested by our Hon'ble President during Chief Minister's Conclave held at Delhi on 6.8.04. He recommended construction of layered wells so as to store the flood water at different levels in order to mitigate the floods and utilize the water thus stored during shortage period. RBA had also suggested for mitigating floods by induced ground water recharge but nothing concrete has taken shape so far. Recently, a study was conducted on this concept by a committee constituted by GOB of which the authors were also the members. The study revealed that the artificial method of recharging groundwater is being practiced abroad for the purposes like:

- i) Meeting increased water demand.
- ii) Improving quality of ground water
- iii) Replacing over exploited aquifers etc. In India, not much has been done at a large scale in this field especially in flood mitigation.

The study has also established that there is distinct possibility of absorption of flood water in the area of study viz., Bagmati- Kamala- Kosi Basin of Bihar by adopting Injection Well method for recharging ground water. This can be achieved by first evacuating the ground water aquifer by pumping ground water before onset of floods and utilizing them for Rabi and H. W. irrigation. This will create the space required in the aquifer to accommodate flood water required to be absorbed. For this purpose, the well will have to be designed to function as Injection cum Irrigation well. Basin/Pit method can also be used for transferring flood water to ground

water aquifer by either spreading flood water in the paddy field with there farm ridges by additional 15 – 20 cms or conserving them in Ponds / Tanks to act as surface detention reservoirs. To start with, pilot projects have been suggested before taking up the work at a large scale.

ROLE OF LARGE DAMS IN FLOOD MODERATION-CASE STUDIES

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Since time immemorial, floods have been responsible for untold misery in survival parts of the world and India is no exception. Valuable property, crops, human beings and livestock etc continue to get washed away during floods. Due to ever increasing pressure of population and economic considerations, encroachments of flood-plains have gone almost unabated, resulting in progressive increase in flood damages. As per the assessment of Rashtriya Barh Ayog (RBA) out of total of flood prone area of 40 MHa, 32 MHa is protectable. An area of around 16.5 MHa has been provided with reasonable degree of protection. In this background, the role of large dams in flood moderation hardly needs any emphasis.

During post-independence period, multi-purpose projects such as DVC reservoirs, Bhakra-Nangal Project, Hirakund dam, Ukai-Kakrapar project, Nagarjuna Sagar project etc. have been constructed to increase food production, energy generation, drinking water supply, fisheries development, employment generation, flood moderation by dams in the country is that of Damodar Valley, where a chain of reservoirs were constructed with flood management as one of the objectives. During monsoon of year 2000, DVC reservoirs through flood moderation have saved the lives and property of people from a possible disaster.

Prior to the construction of Hirakund dam, the Mahanadi delta used to suffer quite frequently at the rate of almost once in every three years from the raging floods. Through construction of Hirakund dam, the flood at

delta head could be controlled significantly. In the pre-construction period during 90 years (1868-1987), 27 years have witnessed high floods in the delta. In the post-construction period i.e. during 47 years (1959-2006), floods in the delta have been reported only in 7 years. Prior to the construction of Ukai dam, floods in the downstream areas were rampant. However, the situation dramatically improved after the building of Ukai reservoir as well as installation of a well- established flood forecasting system. The amount of relief provided by the Ukai dam against floods can easily be gauged from the fact that since completion of Ukai dam in 1972 no flood damage occurred till 1994, 1998 and 2006 flood damages occurred despite significant moderation of flood peak because of negligent flood plain management and severe encroachment in natural waterways in downstream areas. Bhakra and Beas dams, though not specifically planned for flood moderation, absorb peak floods and help in moderating floods.

It won't be an overstatement to acknowledge the benefit offered by these large dams providing the required cushion against the raging floods. All the projects mentioned above have given immense relief to the people in downstream area by not only restricting the financial losses but at times, even saving the loss of lives. In the paper some case-studies, bringing out the role of large dams in flood moderation, thereby significantly reducing the damages on account of floods have been presented.

STRUCTURAL MEASURES OF FLOOD MANAGEMENT WITH SPECIAL REFERENCE TO NE REGION

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Nature has gifted us with invaluable gift of river and water, which has brought along with it the problem of Flood. Humanity has always tried to avoid flood damage by one structural measure or another, but the increase in population and property in flood threatened lands has brought the problem into sharper focus in recent years. Out of 40 mha of flood prone area of the country, 3.58 mha lies in the Northeastern region. The major river systems causing flood and erosion in the region are the Brahmaputra and Barak.

During the last five decades since launching of the National Programme of Flood Management in 1954, 5222 km of embankment and 997 km of drainage channel have been constructed in Assam and its neighboring states. In addition, 110 major shices and 873 anti-erosion works have been taken up for implementation. These short term measures have provided reasonable protection to an area of 1.80 mha and 1.78 mha of area still remains to be protected. Inspite of the measures taken up so far, the average annual damage caused due to flood in the states of the region during 1954 to 2004 is Rs 172.96 crore, out of which average annual damage to the state of Assam alone is Rs 88.14 crore. The maximum damage that had occurred in the State of Assam is Rs 753.03 crores in 2002.

For flood management in the region, Task Force for Flood Management / Erosion Control in its Report published in December 2004 suggested strengthening of existing embankments, anti-erosion works and

improvement of drainage channels as immediate and short-term measures and creation of storage reservoirs in the upstream tributaries as a long – term measure. It has however been observed that of late the states located in the upper reaches of the Brahmaputra have laid more emphasis on power projects as run off river projects submergence and the schemes having multi-purpose characters are being shelved with preference to run of the river power projects. Because of braided nature of the river, embankments have been eroded in many reaches requiring construction of retirement bunds. In many cases, protection measures taken in vulnerable reaches have resulted in adverse affects the downstream reaches or in the opposite bank of the river.

Marked reduction in stage at a specific point on a stream can often be achieved by merely improving the hydraulic capacity of the channel by increasing hydraulic radius, depth, and increasing the channel slope by shortening the channel length. The effect of such improvements on flood heights can be computed by usual hydraulic procedures. It is proposed to confine the flow of the Brahmaputra to a single channel of about 2500 m width between the reach from Dholla to Bessamara with the channel characteristics so designed to pass a discharge conforming to 100 Year Return Flood. Under the present scenario where performance of the short-term measures have their inherent limitations and proposed recommended long-term solution by creation of storages in the upstream is grim because of the change in policy of the upstream states regarding hydropower projects, channelization of Brahmaputra reach by reach appears to be the best possible alternate solution to the erosion and flood problems in the valley.

FLOOD PLAIN ZONING & REGULATION

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The areas prone to floods are termed as flood plains and zoning of these areas is known as flood plain zoning. These areas follow byelaws and legislation of the relevant authorities. Under these byelaws the safety installations and essential services building plinth elevations are kept above 100 year flood level while public place installation / building's minimum elevation is kept above 25 year flood level. Raised platforms are usually provided for shelter of animals and hutments of locals. Flood plain zoning is the legal tool, which is used to implement and enforce the detailed provisions of the land use planning programme. Crop insurance against floods should ideally aim at distributing loss burden over the larger population instead of only affected people in the country. Flood regulation includes erection of flood control structures such as dams, weirs, sluice gates, levees, revetments, groundsills or other facilities intended to increase the public benefit from the water of a river, or to decrease public loss caused by flood or high tide.

COMMUNITY APPROACH TO FLOOD MANAGEMENT

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Every year, during the peak rainfall season, the flow of water in the rivers exceeds the normal volume and result in flooding the plain areas, causing extreme damage to life and property. It is almost impossible for human beings to change the priorities and course of nature, rather the efforts to minimize the loss due to floods seems to be more practical. Flood management, therefore, plays a significant role in mitigating the ill-effects.

Perceptions regarding flood disaster among the people in the affected areas vary from those who are fully cognizant of the disaster to those who are fully unaware of floods as a disaster. Studies of natural disasters show that the government programmes can go astray if they ignore the perceptions of the people concerned in the disaster. All these leads to a conclusion that until and unless the community participates in such programmes, the outcome will remain poor. In a country like India, where flood forecasting and preparedness is just about average, community approach should be preferred, which is people-centred. The participation level of this approach for flood management includes: passive information giving, providing consultation, functional participation and interactive participation. The community approach to flood management involves widespread and frequent interaction with the local people through participatory rural appraisals and focused group discussions, consultation with local level bodies and experts, deciding what the community should do for flood management, raise the public awareness and strengthen self-help capacity. As a result, some fruitful outcomes of this approach are: formation of flood management committees, organizing capacity building training camps,

rescue and relief operations and care of drinking water, health and hygiene aspects which are severely affected on a massive scale during floods.

So far technological advancements have not generated a big impact in flood management. People-centric approach, which focuses more on self-help and is participatory in nature, is the suitable approach to mitigate with the consequences of floods. Involvement of the affected community is the key to success for flood management.

REMOTE SENSING AND GIS APPLICATIONS IN FLOOD MANAGEMENT

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Floods are one of the major disasters, that have been occurring world over since time immemorial and India is no exception. Floods seriously disrupt the functioning of a region causing devastating impact on human life, economy, natural resources and environment. Though it may not be possible to completely control the occurrence of floods, it is possible to minimize the impacts considerably by adopting suitable flood management practices. Efforts to achieve effective flood management have used a variety of structural as well as non-structural measures. In this context, Remote Sensing and GIS technology plays a vital role in providing inputs for flood management.

The unique capabilities of satellites to provide comprehensive, synoptic and, multi-temporal coverage of very large areas at regular intervals have been very valuable in monitoring and managing flood dynamics. In fact, it is only space technology, which has for the first time provided the basic information needed in the space, time and frequency domain. In order that the appropriate flood control and anti-erosion works are scientifically planned, executed, monitored and maintained as per the best standards, it is necessary to acquire timely and reliable information about the flooded areas, watershed areas, river behavior and configurations, etc. prior to, during and after floods. Such information is difficult to acquire in time for decision-making from conventional ground survey methods in vogue, which are arduous, time consuming and beset with various limitations, especially while studying floods *of*; large river basins. Satellite remote

sensing based Post flood configuration maps of rivers help to plan, monitor and review flood control measures. Advancements in the remote sensing technology and the Geographic Information Systems (GIS) help in real time monitoring, early warning and quick damage assessment of flood disasters. Remote sensing and GIS technique has successfully established its application in various areas of flood management such as flood inundation mapping, flood plain zoning and river morphological studies.

The paper presents the various possibilities of using Remote Sensing and Geographic Information System techniques in flood management.

**FLOOD DISASTER MANAGEMENT AND MITIGATION WITH A
SPECIAL REFERENCE TO UPSTREAM OF FARAKKA BARRAGE
IN MALDA DISTRICT IN WEST BENGAL**

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Flood is an intense and recurrent natural hazard in the state of Bengal in the eastern region of India. The mighty river Ganga flows in this region resulting in extensive damage to life and property. Malda district of West Bengal has been the most sufferer, having the highest population in India mostly, poverty stricken. The region fell the victim of the most severest floods in 1954, 1974, 1975, 1976, 1984, 1987, 1988, 1998, 2000 and 2004. Thus, water having the potentiality of delivering the benefits through multi-sectoral developments, jeopardizes the development activities of the region. A large number of flood mitigation measures were taken since enunciation of the National policy on flood management in 1954. All the remedial measures taken (30 Km. embankment, 27 spurs and revetments along-with launching apron at several locations) proved to be ineffective owing to gradual shifting of river towards the left bank upstream of the Farakka barrage and formation shoals (chars) on the right bank. Most portions of the seven retired embankments and spurs have been washed out. Colossal damages to extent of Rs. 10,000 million in a single year of 1998 occurred, inflicting heavy loss to the poverty stricken people of the area. Flood mitigation is essentially linked with poverty alleviation in this area. Paradoxically this region happens to be richly endowed with natural resources in West Bengal.

Flood is essentially a natural hydrologic phenomena with a large volume of surplus water which inundates the flood plains, interfere greatly socio-economic activities of people, an unharnessed energy causes severe bank

erosion rendering enormous irreparable damages. Erosion caused by flood waters imparts permanent loss to the life and property of the people whereas flood inundation is temporary phase and lasts for a few days and is tolerable & repairable. Erosion control is necessary for controlling flood inundation. Severe erosion right from upstream Farakka Barrage upto the Manikchak near Bhutani diara on the left bank of river Ganga in the Malda district, has assumed alarming dimension National problem and has become un-manageable by the State Govt. of West Bengal. This is due to the fact that eight retired embankments with large number of bank protective measures taken by the State Govt. with great efforts have been rendered ineffective despite huge expenditure incurred because of the unpredictable pattern of flow below Bhutani Diara.

The erosion control measures taken during 2005 for a length of 2 Km. by Farakka Barrage Project has proved to be very effective and the most critical area in a length of 2.2 Km. has been protected during 2006 with four changes in the design of earlier remedial measures adopted by Farakka Barrage Project. This paper discusses the most vital factor responsible for bank erosion caused by the river bed erosion leading to failure of protective measures taken to control flood inundation. It also highlights the technique adopted to control the bank erosion consequent to bed erosion and stresses the need to review the laying of launching apron according to the river bed scour.

MODELLING FLOOD ATTENUATION IN THE NATURAL POLDERS OF BRAHMAPUTRA RIVER

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In the Brahmaputra River, flood is almost a regular phenomenon and subsequently causes heavy damage to the region. Due to the occurrence of high intensity storm events in its catchment, high flood waves are formed and then propagate through its riverine which is composed of many natural polders (wetlands). The polders attenuate the flood waves, depending upon both their hydraulic and hydrologic conditions and the hydraulic behaviour of floods. This present study aims to develop an integrated model of hydraulic and hydrological processes in defining both river flow in a large river and its riverine area in order to quantify the flood attenuation.

In this integrated modelling approach, a hydrodynamic model describing two dimensional depth-averaged shallow water equations has been coupled with a three dimensional groundwater flow model. The hydrodynamic model uses the finite volume method in solving the shallow water equations subject to any natural river flow boundary conditions and is capable of defining any complex topography of a river system. The coupled model considers the exchange of discharge flux between river flow and groundwater aquifer zones. The modelling approach was evaluated in a closed riverine area of the river which partly covers the Kaziranga National park. The length of the river is about 63 km long with an average depth of 11 m, but the width ranges between 3 and 7.8 km. The digital elevation model of 90 m interval was used to define the flow

domain. In the groundwater aquifer, hydraulic characteristics of the soil profile were defined. The river flow data pertaining 80-days flood waves was simulated to determine the attenuation and storage characteristics. The simulation results show that the flood peak reduction ranges from 5 to 20%. At initial simulation period, the estimated flood response time of the aquifer was about 10 days later than the channel routing time and reduces the flood peak considerable.

RATIONALIZING FLOOD MANAGEMENT

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Structural measures of flood management provide a well defined and quantified relief from floods. Unfortunately, construction of reservoirs is under a sustained attack from a small but influential lobby. There is no site anywhere in India where construction of a reservoir will not cause displacement. Whether it is fair to displace people from where they have lived for centuries; how to rehabilitate them; an R&R policy that is fair yet workable; how to ensure whether the agreed R&R package is implemented; etc. are issues that need to be settled first. However, those who are opposed to dams for ideological reasons are pushing a theory that dams do not control any floods and all the flood control can be achieved by afforestation and rainwater harvesting. On the one hand, the GoI maintains the need to increase the storage capacity, but, on the other hand nothing is done to counter the misinformation campaign against large dams.

Flood forecasting can significantly reduce loss of life, if not property, in the event of a flood. Unfortunately, the FF technology in India has remained static over the years. Recent advances in atmospheric physics, quantitative rainfall prediction, and advances in IT can significantly improve the flood forecast. But to do that, the discussion has to come out of the phase of proclamation of the power of IT, and enter an application phase. Flood plain zoning and regulation is a very sound idea in theory, but unworkable in practice in a country where population pressures compel the people to live not only close to the river, but between the flood embankments. It is time for a reality check – whether flood plain zoning should be dropped from the list of measures. When a flood occurs, the

problems faced by the people and the relief actions required are all known. What is required is removal of bottlenecks in the decision making process.

Urban flood management is an entirely different problem. In fact “flood” is not even the correct term to describe urban inundation. The term “flood” is used to describe inundation caused by water spilling out from the river, often caused by a rainfall much upstream. This can happen in large cities also, but rarely. More often, urban inundation is caused by inability of the local rainfall to drain out fast enough, and is better described as “drainage congestion”, and not flood. When a rainfall of 944 mm in 24 hours in July 2005 inundated Mumbai, the activists heaped all the blame on illegal and unplanned construction which, according to them, obstructed water flow. An year later, the way the society as a whole has reacted to the demolition and sealing of illegal structures in Delhi, it is clear that a development of the city as per a plan is nowhere as simple and as feasible, as the professional activists in Mumbai wanted everyone to believe. If it is accepted that the development activities in a mega-city can follow a “plan” only to a limited extent, then a certain degree of inundation due to drainage congestion will have to be accepted as a fact of life. However, it must be noted that a comparison of the relief operations in Mumbai in July 2006, and in New Orleans in USA after Katrina a month latter, (despite vast differences in the resources) proves beyond all doubt that Mumbai did much better in managing the situation.

DRINKING WATER MANAGEMENT IN DISASTER SCENARIO: MICROBIOLOGICAL ISSUES

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Lack of safe drinking water is the cause for a large number of deaths in the aftermath of a natural disaster. Providing drinking water to the victims is thus a vital issue in disaster management operations. Microbiological quality of water is the main concern as it generally deteriorates during any disaster scenario. The quality of rivers, lakes, reservoirs and ground water used as drinking water sources get contaminated during disasters. These water sources become polluted with coliform and pathogenic microorganisms from normal, diseased or carrier human and animal excrements. Pathogenic and toxigenic microbiological agents in drinking water can cause diseases and deaths amongst the consumers. Microbiological parameters can provide unique information on water quality that ultimately decides whether the water is fit for human consumption or otherwise. Water quality monitoring at site is thus needed that can provide information necessary to implement appropriate treatment methods. Defence Laboratory, Jodhpur has developed a potable water testing kit which is best suited for this purpose.

The effect of the Super Cyclone (Orissa, October 1999) on drinking water quality was investigated when the laboratory was engaged in the disaster management activity. Various drinking water sources like well water, under ground (pump water), rural water supply samples and canal water in 5 most affected districts of Orissa - Ersama, Gadabishunpur, Balidiha, Kujang (Jagatsinghpur Distt)), Astarang, Bhutapada, Kanhaiya Vidyadharpur (Puri Distt.), Balianta (Khurda Distt.), Cuttack and

Bhuwaneshwar were evaluated. Microbiological testing was carried out using H₂S strip and GCFL medium for rapid detection of coliforms and faecal coliforms developed by the laboratory. Floods had washed away human beings and animals and made water unfit for drinking. Sanitation condition in the affected area was seriously inadequate due to floating corpses of animals and human being, rotting of dead bodies and mixing of sewage with water sources. Eight water purification systems comprising of 5 µ & 20 µ filters, charcoal filter and chlorination treatment were installed at site to supply safe drinking water thus prevented outbreaks of diseases due to intake of contaminated water by the residents.

The above measures undertaken by the lab. proved adequate during the Orissa cyclone disaster operations. However, if the disaster results into other types of contamination in water e.g. salinity, nuclear/chemical contaminants; different technologies will then be required to handle such disaster scenario. Defence Laboratory, Jodhpur has developed mobile water purification systems which can adequately address these disaster situations also.

FLOOD PLAIN ZONING AND REGULATION

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Flood plain Zoning has been accepted four decades back as an important strategy for flood management. The *Rashtriya Barh Ayog* (National Flood Commission) had also reiterated this approach over twenty-five years ago. The central and state governments accepted it for implementation. The National Water Policy places increased emphasis on non-structural measures that include flood plain zoning. The basic concept is to regulate land use in the flood plains by scientifically demarcating areas under different degrees of risk and limit, if not prevent, indiscriminate development in such zones of the flood plains. The paper briefly examines the manner in which this accepted policy has been implemented over the years. It traces the relevant findings of study groups and expert assessments that have examined the pace of the implementation of the recommendations on flood plain zoning, its demarcation and implementation. The paper finds that, for reasons of their own, the state and central governments have not sincerely implemented the policy and must bear the responsibility for this inaction

The implications of the non-implementation of the accepted policy on flood plains regulation are quite serious. This is, virtually, an invitation for a disaster in the flood plains, waiting to happen sooner or later. The paper ends with an examination of what could be done even at this late stage, provided there is a political will and consensus across party lines to implement the policy.

REFORMING FLOOD MANAGEMENT SECTOR

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The flood management sector has come a long way through all of the 10 Five Year Plans. While a huge amount of investment has been made in this sector and substantial flood prone area has been provided with reasonable protection, a lot has still required to be done. The pace of progress is slow owing to many reasons. Integrated flood management is the basic philosophy to manage the flood plains that integrates land and water resources development in a river basin, with a view to maximize the efficient use of flood plains, minimize loss of life and put in place well functioning integrated measures for flood management. This needs a serious thought. We have a number of master plans/comprehensive plans of river basins and area/project specific expert reports on managing floods gathering dust. These need to be implemented in earnest with the right dose of funds.

The states may continue to be reluctant to put their money in the flood management sector. As such, initiative in this regard will have to come from the Centre. A quick look at the funding pattern, right from the First Plan to the current Plan will reveal that the earmarked funds on the subject of flood control and drainage have been dwindling alarmingly. This is true for the Irrigation and Flood sector as a whole. This trend has to be reversed immediately. A paradigm shift has taken place with the time, slowly and inexorably, in the planning departments of the states, adopting the strategy of depending upon flood relief and rehabilitation rather than the desirable strategy of flood disaster preparedness & response planning. Emphasis is more on structural measures. At the same time R & M funds have been

drastically reduced. No distinction is being made between riverine and flash floods in strategizing their management. A thorough overhaul of the sector at the drawing board as well as at the ground level is needed without further loss of time

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MANAGEMENT OF HUMAN SETTLEMENTS IN FLOOD-PRONE URBAN AREAS – A CASE STUDY

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Floods are caused not only by rain but also by man made constructions and changes in the environment. Farming, deforestation, and urbanization increases the runoff due to rains; and storms that previously would have caused no flooding today inundate vast areas. Human settlements in flood prone areas mostly contribute to loss of life and damage to buildings and property. Further, inefficient management of vulnerable areas, poor watershed management, and failure to control the flooding also result in disasters. Ecologists have recently found evidence that human intervention may directly be affecting the weather conditions that produce extensive and heavy rains. Irrigation of dry lands creates moisture conditions that contribute to increased humidity and evaporation, which in turn lead to increased rainfall in urban areas. Heavy rains in urban areas create flooding due to poor drainage conditions. This is particularly so in metropolitan cities and the recent Chennai floods which caused loss of life and property in settlement areas, is the best example. The paper aims at presenting a case study on the flood disaster in Chennai. Based on this study, recommendations are suggested for management of human settlements and planning in flood-prone urban areas. This paper also deals with the effectiveness of the measures taken so far to lessen the adverse impact of floods on socioeconomic conditions. The issues of resettlements of people in flood prone areas are also discussed.

IDENTIFICATION OF FLOOD AFFECTED AREAS- NEED FOR A SCIENTIFIC APPROACH

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Identification of flood affected areas is an important input for taking up flood management schemes for alleviating the problems of the people affected by floods. Rashtriya Barh Ayog attempted in 1980 to quantify the area liable to floods and arrived at figure of 40 m.ha for the country. Subsequently, many states reported significantly enhanced figures of Flood Prone Areas to Working Group for Flood Control Programme for Xth Plan. The Working Group expressed concern about the authenticity of figures given by some of states and suggested a review. The RBA had also advised the State Govts. to work out the flood prone area in a scientific manner.

This paper describes an efficient and scientific approach with suitable illustrations to map near real time flood inundation. Flood inundated areas of some of the districts of Bihar have been worked out for a particular satellite scene to establish the effectiveness of using remote sensing data as a tool to map flood inundated areas. The methodology of identifying flooded area district wise, as discussed in the paper, is topical in view of the District wise Flood Prone Area Development Programme likely to be launched by Planning Commission during XI Plan. The paper also highlights the application of satellite imageries to assess the damage caused by floods.

FLOOD MANAGEMENT IN BAGMATI BASIN

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The river Bagmati has been one of the major causes of flood related disasters in north Bihar. Several studies have been made in the past to control floods with a view to minimize the recurrent damage due to floods in Bihar. The flood embankments have been constructed on banks of the river from Dheng bridge to Runnisadpur for a length of about 50 Km. schemes for extension of embankment upstream in India and Nepal have also been taken up. The results to desired scale are not there. The river system is complex, has tendency to migrate and avulse in adjoining channels in India. Its flood plain is very flat and numerous small and big tributaries join from both the banks throughout its length.

A large catchment area being in Nepal adds an international dimension to the problem. Bagmati Flood Control Scheme and Bagmati Multi-purpose Projects were formulated with a view to harness the river water for beneficial use and control the floods. However, these schemes have not been implemented due to various reasons including frequent changes in river morphology and complexity of the problem. Development of a comprehensive plan needs a large amount of precise and high resolution topographic data, hydro meteorological data, land use /land cover and infrastructure details of the basin. Collection of such data and its analysis is extremely difficult. However, with the technological advancement in the field of computing, instrumentation and software's, analyses are possible with desired accuracy. Based on the hydro meteorological and topographical data available with CWC and that made available by Nepal Government and Bihar Government, CWC has analyzed the problem and

evolved a concept for flood management in the basin. This concept is required to be translated into DPR and an Action Plan for flood management is needed to be prepared by the government of Bihar either on their own or through a consultant.

CWC has also made an attempt to use MIKE 11 a mathematical modeling software tool to simulate the river right from Karmaiya Barrage upstream control structure in Nepal to Runnisadpur, the embanked portion, in Bihar. The model has been calibrated using the available data and the results generated in the form of water levels achieved due to passage of 25 year return flood at the given locations along the river. There is further need for data collection and applying the model for entire river reach till it joins the river Kamla.

FLOOD FORECASTING IN RIVER YAMUNA- A MATHEMATICAL APPROACH

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Flood Forecasting and Warning is a well recognized and time tested non-structural measure used not only in India but all over the world for mitigation of damages caused by the disastrous due to floods. The Central Water Commission started flood forecasting operations in 1958 with issue of flood forecast for river Yamuna and Old Delhi Railway Bridge in Delhi. Since then it has expanded its operations and modernized the technology for collection, compilation, transmission and forecast formulation etc. at present forecasts for 173 sites including Mawi and Delhi Railway Bridge on river Yamuna are being issued by CWC.

Since beginning water level at forecast station is computed by establishing correlation using historical data between water level of upstream site(s) with water level of forecast station, generally called Gauge to Gauge co-axial correlation. With the major advancements in the computing facilities, developments are continuing in replicating hydrological cycle mathematically using high speed computers, software and modeling techniques.

The present method, though quite successful in terms of accuracy has limitations of warning time and it is not able to forecast quantum of water and area likely to be inundated. Therefore, need has been felt to modernize the system of collection, compilation, transmission and modeling the system. In its strive to adopt new initiatives, CWC has developed a computer based mathematical model for flood forecasting at Mawi and

Delhi Railway Bridge on river Yamuhna using MIKE 11, an one-dimensional modeling tool for the simulation of flows. The model has been calibrated using data of the worst floods of 1978, 1988, 1995 and 1998 and validated using data of 2003. The model has been put on trial during current monsoon period. The results are fairly satisfactory.

COMMUNITY APPROACH TO FLOOD MANAGEMENT

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Flood is a natural disaster which man is fighting for decades. Due to the ecological imbalance created by man himself, the damage done by flooding is increasing over the years and more rapidly during recent years. Taking into account the recent occurrences of flood all over the world, it is observed that the extreme floods are turning more often to disaster. Now, it becomes almost impossible for the Governments of the flood affected countries to get rid of flood havoc by involvement of the Government machinery alone. Therefore, it has now become essential to adopt an integrated approach linking land and water uses, flood risks, socio-economic development and the protection of natural ecosystems through appropriate institutional framework and public participation. This approach is termed as 'Integrated Flood Management' (IFM).

In order to tackle the aforesaid Integrated Flood Management, countries like Japan, the Netherlands, France, India etc. have joined together by exchanging the information, knowledge and experience among one another. The World Meteorological Organization (WMO) is supporting the advocacy and implementation of IFM by sharing the accumulated knowledge and conducting the pilot projects to demonstrate the applicability of the 'Integrated Flood Management' concept in the field through the Associated Programme of Flood Management. Flood is a major natural disaster in the Indian Sub-continent. It is creating havoc especially in the Gangetic –Brahmaputra- Meghna plains. Keeping this in view, the World Meteorological Organization started a project entitled 'Community Approach to Flood Management in India. This was part of the

coordinated project covering India, Nepal and Bangladesh having a common and collaborated research design. The broad objective of the project was to find out ways and means for strengthening the self-help capacity of the flood affected community particularly at village level for the improvement of the flood management practices under the Integrated Water Resource Management framework. The aspects of public participation which in larger profile is termed as community approach in the field of flood management, depends on number of factors such as formation of the self help groups with the involvement of NGOs, selection of location, proper functioning of village level office like Gram Panchayat, steps for educating villagers, perception of villagers, social composition, recurring flood experience, surface communication link, establishment of wireless communication network, livestock loss management, crop damage control, sanitation and health care, stopping of epidemics, migration, interaction with villagers and pre-flood, during flood & post flood activities, constitution of flood management committees, empowerment through capacity building, training on agriculture, plantation & aquaculture/ fish culture, training on rescue, temporary flood shelter & relief operations recording of events, relief management, restoration of normalcy, resource mobilization community contribution, taking up crop rotation and crop culture and formation of small income generation groups etc.