



Disaster Management-Control & Prevention Of Flood In Uttarakhand

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Abstract: India is a very densely populated country with population over 1.25 billion people and experiences natural hazards like floods and drought simultaneously at the same time in the country causing severe damages because of its different geographical terrains. Earthquakes, cyclones, and landslides are other natural calamities, which affect the various parts of the Country on one or more occasions. Uttarakhand, predominantly a hilly State, also experiences floods, landslides and earthquakes very often.

The Devi Bhoomi of India, Uttarakhand is one of the major pilgrimage sites in India with devotees coming from across the globe, yet the states have to face major wraths of God in the form of natural calamities such as flash floods, cloud bursts, earthquakes, etc. The average rainfall of Uttarakhand state is 1299mm which results in constant flooding in low-lying areas like Chamoli, Bageshwar, etc. Climate variability and change, as well as the likelihood of negative effects on the intensity and frequency of flooding, necessitate a long-term solution. Thus, there is a constant need for sustainable approaches for flood protection and management which uses not only large structural flood defenses like dams, storage reservoirs, and embankments but also advance GIS techniques, WSN for Glacier Lake Outburst, etc. This paper discusses various aspects of management for floods which can be used in a state like Uttarakhand like, Integrated Flood Management (IFM), Satellite Remote Sensing and GIS Techniques, Structural and Non – Structural Flood Protection Measures and Wireless Sensor Network (WSN) for Flood Management.

Index Terms - Floods, Disasters, Cloud Bursts, Uttarakhand, GIS, WSN, Flood Defense Structures.

1. Introduction:

Uttarakhand is a multihazard prone state, vulnerable to earthquakes, landslides, floods and soil erosion. Human-induced disasters resulting from unplanned development of land, forests, river basins and flood plains are also on the rise in Uttarakhand. Significant population growth, at a rate greater than 250% from 1901-1991, has also compounded the pressure on the ecosystem.

The state has forests covering around 64% of its area. Major rivers like Ganga, Yamuna and Kali and their subsidiaries flow in Uttarakhand, fed by various glaciers. The Hindu Kush Himalayan region is one of the poorest regions of the world, inhabited by about 40% of the world's poor, with population density as high as 180 persons per square kilometre. Twenty nine percent of the people living in the Indian part of this Himalayas have income below the national poverty line with an annual population growth rate of 1.4 % and infant mortality rate of 63 per 1000 live births (Shrestha B. Arun et al. 2013).

Thus, Uttarakhand has to be prepared to cope with such disasters, especially when it is not possible to prevent them. The Disaster Management Plan for each district has to be prepared involving all the stakeholders. Preparedness also involves the establishment of early warning systems with last mile connectivity. There is need to systematize the visit of tourists to these areas with available technology. There is also a need to establish a State Disaster Response Force (SDRF) for timely response to natural disasters.

Policymakers need to mainstream the disaster risk reduction in their developmental plans. With climate change, extreme events such as this are expected to increase, which will necessitate community-based sustainable disaster management practices. Early return to livelihood should be the goal of all these measures.

Natural catastrophes such as Himalayan tsunamis, flash floods, earthquakes, landslides, hailstorms, cloudbursts, snow avalanches, soil erosion, and forest fires are common in Uttarakhand, resulting in the loss of lives and property. This tragedy hastens the expansion of the mountainous state's development. Human intervention and activities such as haphazard development and land use patterns, deforestation, rising visitor numbers in environmentally sensitive areas, and improper land use and waste disposal practises all contribute to the occurrence of risks [Uttarakhand Disaster report 2013]. Floods has been a leading cause of disastrous death in Uttarakhand. Landslides, floods, earthquakes, hailstorms, and avalanches are common in the state's hill region, whereas floods and water logging are more common in the Terai and Bhabar regions Uttarakhand Disaster report 2013] [India Disaster Report, 2013], (A. Devasena and B. Sowmya, 2015). There is a constant need of flood protection and its control. In this paper we discuss about some of methods which will significantly help in flood control in Uttarakhand.

2. Integrated Flood Management:

IFM is a concept for integrated land and water resource development that aims to maximise net benefits from flood-prone regions while decreasing flood losses at the same time (APFM 2004). The objective of balancing development requirements, environmental quality, and flood hazards to enable sustainable development is a unique idea (Grabs et al. 2007). Managing flood risk and uncertainty, establishing an

appropriate mix of flood management methods, and supporting a participatory process are all important aspects of IFM (APFM 2004). Restoration Ecology, Flood Management, Integrated River Management, Ecosystem-based Adaptation (EbA), and Eco-based Disaster Risk Reduction (EcoDRR) are some of the disciplines and frameworks that have been used to adjust flood-prone land uses. Though they come from different schools of thought and are aimed towards different goals, these methods all have one thing in common: they restrict and modify land uses in flood-prone regions while permitting rivers to temporarily flood broad areas (Clarke et al. 2003, Klijn et al. 2004, van Eijk et al. 2013).

2.1. Interdisciplinary approach of IFM

To choose the best flood-management alternatives in a particular hydrometeorological and geographic scenario, integrated flood management requires careful evaluation of socioeconomic, environmental, legal, and institutional factors. It necessitates contributions from a variety of disciplines, sectors, and stakeholders, many of whom have competing interests. Various institutions and organisations participating in development efforts that impact or are affected by flood-management measures must coordinate their actions to ensure that they do not lead to a rise in flood hazard and, as a result, flood risks (W. Grabs et al. 2007).

2.2. Ecosystem preservation

Flood control is critical for both people's safety and socioeconomic growth. However, the efforts, which primarily depended on structural solutions (dams and reservoirs, embankments, bypass routes, and so on), have harmed the river's natural ecology (WMO, 2006(b)). At the same time, from the standpoint of flood control, environmental deterioration has the potential to endanger human security in a variety of ways (Mechanism for enabling MEA, 2005).

2.3. Vulnerability and risk reduction

Flood risks are determined by the size of the flood danger, the extent to which development activities are exposed to such hazards, and the susceptibility of such activities. The basin strategy helps to avoid the flood threat from becoming more severe. The ability of potential flood disaster victims to deploy the assets at their disposal to face the task provided by the flood danger vs the magnitude of the problem determines their "vulnerability." More broadly, the flood-resilience of development operations must be improved in order to preserve or improve the quality of life and avoid floods from becoming disasters (WMO, 2006(a)).

2.4. Providing opportunities for community participation

Increased community involvement helps to decrease vulnerability. Participation in the decision-making process lays the path for success in flood-prone areas in order to create resilience. Community involvement encourages decentralisation of administration to the lowest level possible and ensures that trade-offs be made peacefully, guaranteeing development equity (WMO, 2006(a)).

2.5. Mechanism for Enabling

To put integrated flood control techniques into reality, an enabling mechanism is required, as well as suitable legislation and regulations. Responsibilities and duties among institutions and persons should be specified in pre-flood, during-flood, and post-flood circumstances so that their roles are clear, and a coordination system may be developed (WMO, 2006(c)).

3. Flood Disaster Reduction Strategy:

The concept of flood disaster reduction strategy is centuries old and with time they have been updated regularly with the advancement of technological development. But, till today, in spite of decades of flood damage reduction strategy, flood losses continue to rise.

Intergovernmental Panel on Climate Change(IPCC) in the late 1980s had also realized the impact of climate change on natural disasters in general and flooding in particular. In early 1990s, the process of flood disaster reduction strategy was introduced in flood management. In the late 1990s, risk-based approaches were used by the researchers in developing flood management strategies. Later in 2000s, strong defense structures were suggested to be used to increase safety. However, there has been a general agreement that absolute safety from flood hazards is not possible and therefore acceptable risk levels be also considered for providing flood safety.

Misconceptions and myths about floods and flood defenses are deeply rooted in our society. Many people believe that floods occur at large and regular time intervals and terms such as *return period* and *recurrence interval* can be taken literally, where as one has to understand that these are statistical terms and be taken as averages. However, due to the hydrological and climatic uncertainties, flood risk assessment has remained a challenging task, to date, for all the countries. Thus it can be said that it is better to protect against floods up to a desired safety level. The Central Water Commission, Ministry of Jal Shakti, Govt. of India has already defined these levels in terms of return periods for urban and rural habitats. Once we clearly understood that no flood defense measures can guarantee complete safety, a general change of paradigm is needed from reactive to proactive approach and emergency action plan must be prepared for events exceeding the design flood, adopted for flood defense(i.e. when protections provided are bound to fail). Thus, it can be said that attitude of *living with floods* and preparing Standard Operating Procedures(SOPs) for extreme events seems to be more sustainable strategy rather than hopelessly striving to protect for all conditions.

Long term and short-term structural measures and non-structural measures are the two essential primitives of any Flood Disaster Reduction Strategy. In the structural measures, the floods are kept away from the people and the non-structural measures try to keep the people away from floods. Among the various structural measures, new flood defense/mitigation structures constructed by the State of Uttarakhand after the 2013 disaster and some of the Non-Structural measures adopted by the State of Uttarakhand has been presented in the paper.

4. Satellite Remote Sensing and GIS Techniques:

A Geographic Information System (GIS) is a computer-based system that can handle geographical data by providing input, data management, data storage and retrieval, modification, analysis, and output (Aronoff, 1995) (G.D Bhatt et al., 2013). GIS provides a wide range of techniques for determining flood-prone regions and forecasting areas that are likely to be inundated owing to a river's rising water level (Suia, 1999). The major advantage of GIS for flood management and planning is that it produces a visual representation of flood-prone regions, which allows for additional analysis of the product to estimate flood damage (Hausmann, P. and Weber, M., 1999) (Clark, 1998). The major focus in this discipline is on flood zone delineation and the production of flood hazard and risk maps for susceptible regions (Merz, B et al., 2007). Because of their significant reliance on agriculture, river flooding is a major problem in Asia's emerging countries, yet any attempt at flood estimation and hazard mapping in this region is hampered by a lack of high resolution DEMs (Sanyal, J. and Lu, X.X, 2004). Flood hazard mapping is a critical component of flood-prone area land use planning. It generates easily accessible charts and maps that help administrators and policymakers identify risk regions and prioritise mitigation and response activities (Moel, H et al., 2009).

Risk maps may be generated utilising GIS-based hydrological measurements of the frequency, size, and duration of flood occurrences, as well as DEMs that describe the topographic basin within which flood events occur (Borga, M et al., 1998) (Lastra, J et al., 2008). Flood risk maps may be used to spot flaws in a flood defence system as well as patterns of human infrastructure and animal habitat susceptibility. This research shows that data obtained from various types of imaging can be useful to operational users for flood preparation and emergency response (Aronoff, 1995).

5. Flood Plain Zoning

The basic concept of flood plain zoning is to regulate land use in the flood plains to restrict the damage caused by floods. Flood plain zoning, therefore, aims at determining the locations and the extent of areas for developmental activities in such a fashion that the damage is reduced to a minimum. The Central Water Commission, New Delhi 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 has also circulated by the Government of India to all the States. But there has been a stiff resistance on the part of the states to follow-up the various aspects of flood plain management including possible legislation. The State of Manipur enacted the flood plain zoning legislation way back in 1978 and Rajasthan in 1997, but they have not taken any action to enforce it. The reluctance of the states to enact flood plain zoning regulation is mainly due to population pressure and want of alternative livelihood systems. The lukewarm response of the states towards the enactment and enforcement of the flood plain regulations has fuelled a significant increase in the encroachments into the flood plains.

5.1. Enactment of Flood Plain Zoning Act in Uttarakhand

State of the Uttarakhand is the 3rd State in the Country, who has enacted the Flood Plain Zoning Act in the Country after Manipur and Rajasthan and first to implement the same for flood management. In the first phase, flood plain zoning study in the Uttarakhand State was carried out for 55km stretch of river Ganga in Haridwar and 10km hilly stretch in river Bhagirathi in Uttarkashi town. The sample inundation maps for the river Ganga in District Haridwar and river Bhagirathi in Uttarkashi town have been depicted in the Fig. 1 and 2 respectively.

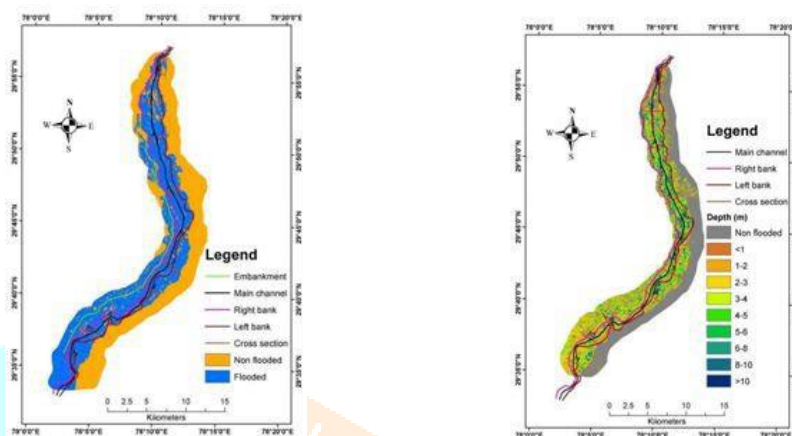


Fig. 1– Flood Inundation Mapping for river Ganga in District Haridwar for 2013 flood

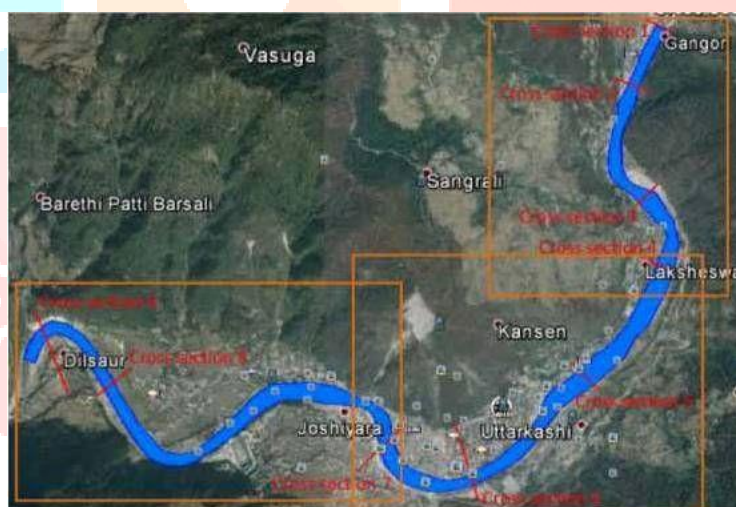


Fig. 2 - Flood Inundation Mapping for river Bhagirathi in Uttarkashi Town for 2013 flood

On the basis of the study carried out by National Institute of Hydrology, Roorkee[NIH, 2017] for the Irrigation Department, Uttarakhand, the 55km stretch of river Ganga and 10km stretch of river Bhagirathi was divided in to two zones, namely prohibited zone and restricted zone on the basis of return periods of 25 year and 100 year flood. Prohibited Zone and Restricted Zone for river Bhagirathi and river Ganga were marked on the Maps/Sajra Sheets and then as per the provisions of the act, the gazette notification in this regard were published in the newspapers, website, district administration offices etc. and objections were invited from the inhabitants in the area, whose land/building was falling in the prohibited zone or restricted zone.

In 10km hilly stretch of river Bhagirathi in Uttarkashi town, it was observed that the anticipated levels for the 100-year return period are below the top level of the bank protection wall constructed all along the river and accordingly the Gazette notification has been issued by the Govt. Where as the Govt. is in the process of finalizing the prohibited and restricted zone for the river Ganga in District Haridwar. For other rivers, the

process has been initiated by the Irrigation Department, Uttarakhand and prohibited and restricted zones will be marked on all major rivers in the State and accordingly flood plain zoning authority shall take actions as per the provisions of the act. It will thus enhance the safety of the people residing along the banks the rivers.

6. Wireless Sensor Network (WSN) for Flood Management

WSNs can be used for flood management using water level monitoring. This construction may be used in any Uttarakhand area with a Glacier Lake and valley. Sensor nodes can be placed on either side of the target region (Glacier Lake). The sensor, which will continually monitor the parameter and communicate this information to the local sink, can be a pressure sensor, piezoelectric sensor, vibration sensor, or a water level detector. The sensor nodes and sink nodes are linked together through a wireless connection. The data acquired from the different sensor nodes will be sent to the base station via the sink node. The connection between the sink and the base station might be a regular wireless link or a WiMAX connection [Krishna G et al., 2013]. This information will be transmitted from the base station to the gateway, which will then be routed to the local server and backbone network. The information will be sent over the backbone network to the nodal centre, where choices will be made. In the event of a backbone network breakdown, the local server and database will be helpful, and it will be monitored by local management. In the event of an anomaly in the lake's water level or pressure, preventive steps can be taken to prevent tragedy and limit damage (Pant, D et al., 2017).

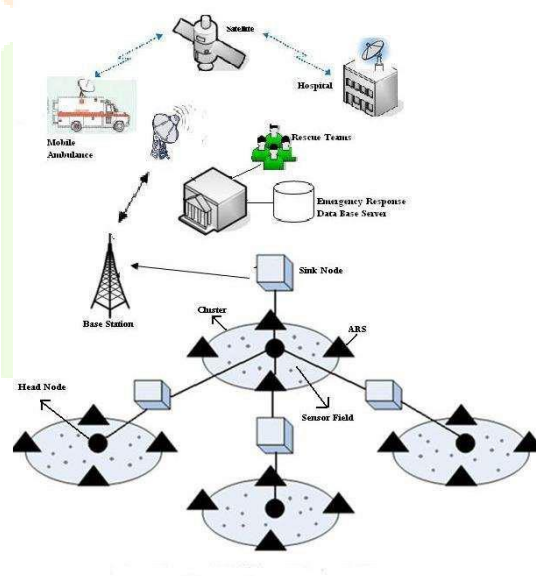


Fig.3 : WSN for flood Management ((Harminder Kaur, 2012))

7. Structural and Non-structural Flood Protection Measures

A list of techniques for decreasing flood losses through flood prevention and management, as well as examples of specific actions, is available. It's usual to think of flood protection as either structural (hard) or non-structural (soft). Dams and dikes have been erected for at least four thousand years; thus, structural fortifications have a long history. River dikes protect nearly all floodplain regions in Hungary. By building reservoirs to hold extra water, streamflow may be distributed more evenly throughout time, with the natural peak flow lowered.

The term "structural" is commonly understood to refer to large-scale defences like as dikes, dams, and flood control reservoirs, as well as diversions, floodway, and other forms of channelization that improve channel conveyance capacity. Then there are soft methods, which are dispersed, small-scale structural approaches like flood proofing. Source control (watershed/landscape structure management), laws and regulations, zoning, economic instruments, an efficient flood forecast-warning system, a system of flood risk assessment, awareness raising and improving information, flood-related data bases, and so on are examples of non-structural flood protection measures (Kundzewicz and Zbigniew W, 2009).

7.1. Relocation and Zoning

Preventative measures, like as zoning and floodplain development restrictions, are unquestionably beneficial. If, however, endangered areas have already been built, individuals and infrastructure can be relocated out of harm's path. The US Interagency Floodplain Management Review Committee was formed in the aftermath of the Great Flood of 1993 (IFMRC, 1994; Galloway, 1999). The administration should subsidise the acquisition of flood-prone land and structures from willing buyers in the floodplain, according to the report. The number of families evacuated from the Mississippi Basin's susceptible floodplain areas is on the order of 20,000 (Galloway, 1999), and it is still growing. On a worldwide scale, benign population growth control, achieved through family planning and fertility reduction through improved living conditions, is an essential self-sustaining strategy. Floodplain settlement would be more limited if there was less demographic pressure. (Kundzewicz and Zbigniew W., 2009).

7.2. Insurance, assistance, and post-disaster recovery

Flood readiness requires the presence of adequate insurance systems, which distribute risks and losses over many people and over a long period of time, as well as disaster relief, which is the ability to replace losses not covered by insurance. These procedures are required to assist flood victims in recovering from their losses. National leaders and the media who have left the natural disaster region have become uninterested, thus post-flood recovery is frequently less dramatic than actions during the flood. Disaster relief, based on volunteer solidarity contributions, state support, and international assistance, is critical in restoring survivors' livelihoods and jobs (Kundzewicz and Zbigniew W.2009).

7.3. Management of Watersheds

Floodwater formation is influenced by source control. This idea is part of a larger category of watershed management that includes terracing and contour ploughing to reduce surface runoff, erosion, and sediment transport, as well as plant cover management and afforestation. The concept of "catching water where it falls" is accomplished by techniques such as improved infiltration, reduced impermeable area, and increased storage through ponds or artificial storage (Kundzewicz and Takeuchi, 1999). Improving retention mitigates the negative consequences of urbanisation, such as a reduction in storage capacity, an increase in flood peak, and a decrease in the time-to-peak of a hydrograph. Increased storage in the river system should be part of watershed management (floodplains, polders, washlands) (Kundzewicz and Zbigniew W., 2009).

7.4. Forecasting and Warning of Floods

Non-structural flood protection measures such as flood forecasting and warning are extremely significant. Human lives can be saved thanks to flood forecasts and warning systems. Experts may translate information on past-to-present rainfall, moisture status, and snow cover into a river flow estimate using forecasting, which is based on mathematical modelling (discharge, stage, and inundated area for a future time horizon). The time lag between an intensive precipitation and the flood peak is relatively brief in small catchments and flash floods. As a result, radar deployment and quantitative precipitation forecasting are required. A big river may take many weeks to propagate a flood wave, giving enough time for flood forecast action. Many attempts have been made to enhance prediction accuracy and extend the time horizon for a useful forecast. Using atmospheric-oceanic-hydrological connections is one difficult option. Accurate predictions should be converted into accurate warnings, which should be widely and successfully distributed to at-risk populations so that they can adopt appropriate loss-reduction measures (Kundzewicz, 2009).

8. Planning for Flash Floods:

High intensity rainfall events in the Himalayan region are often localized and have important implications for flash floods. These intense rainfall events, also known as cloudbursts, occur in remote areas as a result of topographic variations. An example of this is the Leh cloudburst that occurred in 2010. Cloudbursts sometimes even remain unreported due to inaccessibility of the regions where they occur.

The frequency and intensity of flash floods, especially in the Himalayan region is increasing. Intense rainfall events occurring in the high reaches of a mountain stream in an unpopulated area will produce a flash flood affecting the downstream communities, as occurred recently in Uttarakhand in June 2013. These flash floods started on 15 June 2013, and affected around eight districts of the state (Solutionexchange-UN.net.in, 2013).

The situation in Uttarakhand deteriorated further due to landslides triggered by rainfall and floods. Meteorologists at the India Meteorological Department have suggested that though the extreme weather events are not uncommon in Uttarakhand, a possible cause of the copious rainfall could be the fusion of westerlies, which triggered flooding in Central Europe, with the south west monsoon over north India.

Countries in the Hindu Kush Himalayan region, including India, lack policies and strategies for specifically dealing with flash floods. Most of the existing policies relate to riverine floods or to disasters in general. In India, flood management is organized at the central, state and local levels. The central level provides guidance to the states, which implement flood management at the field level (Shrestha B. Arun *et al.* 2013). The National Disaster Management Authority has developed Guidelines on Management of Floods (2008) and Management of Urban Flooding (2010).

9. Coping with Disaster:

The Disaster Management Plan for each district has to be prepared as a first step taking in to account the specific needs of the area, its hazards, risks, vulnerability and, of course, the capacity. This will need detailed mapping, involving all the stakeholders, especially the community, for whom Disaster Management Plan is being prepared. This has to be followed by a number of mock drills to find the gaps and take corrective measures.

The Disaster Management Plan also needs updation at regular intervals depending on the developmental activities in the area. Involvement of the community brings in a sense of responsibility among the community and understanding of the process of development.

The preparedness, apart from the above measures, also involves the establishment of early warning systems with last mile connectivity so that the information reaches in time, without much human intervention. An example of such a system is the Tsunami warning system being developed by INCOIS under the Ministry of Earth Sciences. Community involvement in early warning systems will foster the realization that development should not lead to disasters.

There is an urgent need to systematize the visit of tourists to these areas, with the available technology. There is an urgent need for State Disaster Response Force (SDRF) in the multi-hazard prone states, along the lines of the National Disaster Response Force (NDRF) established by Government of India. This will reduce the response time due to its location in the state and the familiarity with the area and prior experience of disaster management there. Research shows that capacity development is more cost-effective than any other measure in coping with disasters all over the world. Massive scale capacity development, especially involving the energetic youth of the area, is warranted. The sensitization of planners and people's representatives at regular intervals further strengthens the disaster management system.

10. Conclusion:

Over the period of time, since centuries, several flood disaster management strategies have been evolved, but till date it has been a challenge to frame versatile flood disaster management strategy because of uncertainty in climatic changing conditions and river morphological characteristics. Therefore, it is better that flood protections be made to a pre-decided desired safety level, depending upon the prevailing conditions and flood risk. Once we accept that safety cannot be guaranteed/achieved in all the conditions, a paradigm shift is needed in terms of proactive approach to reduce human vulnerability due to floods and an emergency action plan for extreme events be prepared in advance. Thus attitude of *living with floods* and preparing Standard Operating Procedures(SOPs) for extreme events seems to be more sustainable strategy rather than hopelessly striving to eradicate them. Structural and Non-Structural Measures adopted by the Govt. of Uttarakhand will facilitate the planners, administrators and other stake holders of other States of the Country to plan such measures.

In this paper, we have presented various type of flood management system with special emphasis on the sustainability of given approaches. A paradigm shift is required since a flood protection system that guarantees perfect safety is an illusion. Rather than futilely attempting to eliminate floods, it is important to

live with the knowledge of their possibility and to prepare for them. It is critical to raise flood risk awareness among the general people. There is always the chance of a larger flood, causing losses, no matter how high a design safe flood is.

States like Uttarakhand which is prone to disaster has to utilize advance methods for flood protection because these disasters not only ruin the lives of so many families but also makes it impossible to enhance the economy of state. One of the vital things which the authority can use is pre-flood management via technologies like GIS and WSN as mentioned in the paper so an alert can be raised if the disaster is inevitable. In most cases, an efficient flood protection system consists of a combination of structural and non-structural elements. These techniques are more in line with the ethos of long-term growth and align with the sustainable development philosophy.

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