Use of Information and Communication Technology in Flood Management

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Abstract— Floods cause maximum damage throughout the world. 37 % of Natural disasters in India are floods which cause maximum damage. This paper studies "The Real Time Stream Flow Forecasting and Reservoir Operating System (RTSF & ROS)" in Krishna and Bhima River basin, an ICT tool which provides single platform for accessing collected and processed data to manage floods in Maharashtra. The paper studies defining features of this system, challenges in its implementation and suggests practical solutions to leverage data, information, and monitoring capacities available with the RTSF & ROS to create risk knowledge, an innovative early warning mechanism ensuring last mile connectivity to achieve the targets set by the Sendai Framework of Action for disaster risk reduction and sustainable development.

Key words: Flood, Disasters

I. Introduction

A flood is caused due to water overflowing over usually dry land, due to excessive rainfall or other natural disasters. 44% of deaths caused due to natural hazards were due to floods alone [1]. In 2015, the UN released a report called "The Human Cost of Weather Related Disasters," which revealed that around 1.5 billion people were severely affected due to floods in the last 20 years and approximately 200,000 people had lost their lives due to flooding in the same period. There have been 3062 floods since 1995[2] and they have given rise to a plethora of problems for the affected nations. According to the United Nations report, around 3.7 billion people [3] in Asia alone were affected due to floods since 1995, and 300,000 people lost their lives [1][4].

The Indian subcontinent is located in the middle of the summer-monsoon belt. About 75% of the total annual rainfall is received in the four monsoon months, i.e. June to September [5]. As a result of this geographical setting, flood situations are experienced in many parts of the country during these four months [6]. In the past 50 years, total deaths recorded in all these floods were about 30,000 and over 347 million people were affected with economic losses to the tune of 41.9 million USD [7].

Maharashtra is highly vulnerable to floods as most of its districts witness floods during monsoon resulting in huge socio-economic losses. These floods mainly result from damage to the dam embankments, release of excessive water from dams, improper storm-water drainage systems and unplanned urbanization. The state is also vulnerable to floods because of heavy water discharges from the dams in neighboring state of Madhya Pradesh [8]. Non release of water from Allmatti Dam in Karnataka causes flooding of the districts of Sangli and Kolhapur. Increased migration and rising population due to urbanization exerts tremendous pressure on the existing storm-water drainage system in the cities because of which many cities in the state increasingly witness flash floods.

The adverse impacts of floods often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures encompass engineering techniques and hazard-resistant construction as well as improved environmental policies and public awareness. Although these physical measures to manage floods exist, they cannot account for predicting, monitoring and communicating important details about flood occurrence that are essential to reduce the damage caused. However, in the 21st century, the existence of technology has made it possible to predict, monitor and effectively communicate information about floods that can significantly reduce their negative impacts. Thus, use of information and communication technology (ICT) in flood management can equip disaster managers to create a powerful database for real-time information of water status, build a vibrant social network among local and urban communities to make them more informed, and to disseminate crucial information on a large scale to make them resilient and responsive.

II. Use of ICT in Flood Management in India

One of the targets of the Sendai Framework for Disaster Risk Reduction is substantial increase the availability and access to multi-hazard warning systems and disaster risk reduction and assessment to people by 2020 [9]. The Asia Pacific Disaster Report 2015 claims that the information is scarce in many Asia Pacific developing countries which do not have systems to provide precise early warning for disasters which may be useful for reducing the impact [10]. However, the Government of India has made significant efforts to incorporate ICT in management of its water resources. It has developed a system called India-WRIS Web GIS also known as "Generation of Database and Implementation of Web Enabled Water Resources Information System in the Country." India-WRIS Web GIS is a joint effort by the Central Water Commission (CWC), Ministry of Water Resources, Govt. of India, and the Indian Space Research Organization (ISRO), Department of Space, Govt. of India. Their goal is to provide "tools to search, access, visualize, understand, and analyze the data for assessment, monitoring, planning, development and finally Integrated Water Resources Management (IWRM)"[11].

III. Real Time Stream Flow Forecasting and Reservoir Operating System (RTSF & ROS)

Under the framework provided by the central government, the State Government of Maharashtra has developed its own model of incorporating ICT with respect to flooding in the Krishna and Bhima river basins of the region. It has developed the Real Time Stream Flow Forecasting and

Reservoir Operating System (RTSF & ROS) for the Krishna and Bhima Basins, which provides a single platform for accessing collected and processed data to manage floods in the State [12].

Krishna River covers about 282 km in Maharashtra and its basin covers an area of 69,967 sq. km, which is about one third of its total area. Its three main tributaries are Koyna, Warna, and Panchganga; it also has 10 major and 9 medium sized hydroelectric projects [13]. The Bhima river, on the other hand, covers about 451 km in Maharashtra which is more than half of its total length and its basin which includes its tributaries viz. Kundali, Ghod, Bhama, Indrayani, Mula, Mutha, and Pawana covering an area of 48,853 sq.km [14]. The Bhīma river system has 20 major and 7 medium reservoirs. Both the river systems together cover about one third area in the state covering large number of big and small towns which are vulnerable to floods during monsoon floods causing loss of life and property. Higher precipitation increases the risk of floods in the river basin [15]. The forecast given by RTSF and ROS is based on the rainfall in the river basin which equips the government for better flood management of the Krishna and Bhima river basins in Maharashtra Some of the defining features of the Real Time Stream flow Forecasting and Reservoir Operating System (RTSF & ROS) for the Krishna and Bhima basins in Maharashtra are as described

IV. Extensive Knowledge Base

The Knowledge Base System (KBS) is a computerized online system made available as a part of RTSF & ROS for the Krishna and Bhima basins in Maharashtra to provide all the relevant information and tools to analyze information to key stakeholders. The system has data about all historical hydro-meteorological data, river flows and levels, irrigation data, reservoirs data, available satellite images, and other geographical information systems data. The system is also flexible enough to allow stakeholders to constantly make new additions to the database and thereby expand the knowledge. In addition to providing a large amount of relevant data, The KBS also provides tools to effectively analyze this data so that management strategies can be incorporated accordingly. It also sets up accessible web pages with access to the general public, so that they can access information on the current water levels of the rivers and reservoirs.

A. Effective Modeling System

The RTSF & ROS for the Krishna and Bhima basins in Maharashtra has a series of models that are based on the knowledge base and are made available to the public on mobile platforms. The State Government has partnered with DHI which is a global private company that provides all data collected to a large number of people using their unique software. As a part of the RTSF & ROS for the Krishna and Bhima basins in Maharashtra, the DHI has created a number of effective models using their software that can be easily disseminated among the local population. They have created a customized model specific to the Krishna and Bhima river basins that provide real time data and analysis of the condition and status of the two basins. The software also allows for warnings to be issued if the conditions are predicted to be abnormal based on the models.

B. Real Time Data

As a part of the RTSF & ROS for the Krishna and Bhima basins in Maharasthtra, automated rainfall stations have been set-up along the entire Krishna and Bhima river basin. These stations collect and report information about the amount of rainfall in the specific region in real time. The real time data also includes an index of water level correlated with a color to visually show the nature of the rainfall pattern, e.g. Red = very high rainfall and White = normal rainfall. This makes it easy to visualize the distribution of rainfall and predict where floods might pose a problem. The data is updated half hourly. Along with automated rainfall stations, the system also includes the establishment of full climate stations across the two basins and thus the real time data shows the amount of solar radiation, humidity, temperature, air pressure, wind speed, and other parameters pertinent to the specific regions along the basin in real time. This provides an overall idea about the regional climate.

C. Real Time Forecast

The system provides real time forecasts based on historical and real time data. Gauge and discharge correlation diagrams are developed with due travel time. In addition, the rainfall and quantitative precipitation forecast (QPF) for the intermediate catchment is also used to update the forecast. A forecast of 24 hour lead time is calculated and issued to user agencies through telephone/wireless or a special messenger. The real time forecast is seen on the website www.rtsfros.com/mahakrishna/ an, which is available to public as open source. The web site provides information about the water discharge, the water level in the basin, amount of rain fall, and the level of water in the reservoir. This information can be used by anyone to estimate the extent of flooding. The web site also generates alerts and warnings when required.

D. Capacity Building

Another silent feature of the RTSF & ROS is the capacity building module. The project seeks to build technical capacity amongst the operators of the systems. Geographic information systems (GIS) along with remote sensing have emerged as a powerful tool for handling spatial and non-spatial geo-referenced data and integrating with hydrological and hydrodynamic models. To understand the capabilities of remote sensing and GIS, training on remote sensing & GIS and its application to water resources were organized. As the basics of hydrological and hydraulic and modeling approach in these fields are immensely important to this project, the training on introduction to modeling, open channel hydraulics, hydrology, rainfall-runoff modeling and river basin modeling were conducted during the initial phases.

V. Operation of the Flood Forecasting System

The RTSF & ROS for the Krishna and Bhima river basins in Maharashtra is managed and operated by the Flood Control Cell in Pune, Sinchan Bhavan, which is headed by the Executive Engineer, Khadakwasla Irrigation Division. It monitors the information continuously during the four months of monsoon (June to September). The Flood Control Cell collects the reservoir levels, rainfall and spillway discharge for each of the reservoirs twice a day (0700 hrs and 1700 hrs) in normal circumstances and every hour during floods. The data is received by any available means of communication, viz. cellular phones, wireless, landlines, etc. The flood forecasting work of the entire Krishna basin is carried out by the Central Water Commission (CWC) from its Lower Krishna Division, Hyderabad. However, Kurundwad in Kolhapur district on the Krishna river is the station in Maharashtra where forecasts are issued by the CWC. The CWC uses a correlation method for flood forecasting. Karad is the upstream base station on river Krishna for flood forecasting at Kurundwad. The contribution of the tributary Warna is recorded at the Samdoli station. During monsoon, forecasts are issued daily. In the event of high precipitation in the catchment areas, warnings are issued to all the respective district authorities and the local community using telephones, wireless, and messengers [16]

VI. Current Use of the System in Flood Management

The RTSF & ROS is useful in minimizing flood induced losses in the indicated regions through flood forecasting and warning. Flood forecasting is divided into two main categories as recommended by the National Disaster Management Authority [17][18] the short term forecast, which is based on the rainfall and the discharge of water in the river channel, amend the long term forecast, which is based on the study of the entire season which the help of IMD and simulation models. The long term forecast is used to keep the population on an alert on the predicted days and based on further short term forecasts, people may evacuate if required. The short term forecast is used for issuing warnings in case of floods. These warnings are issued to the District Disaster Management Authorities, various departments of the government like agriculture, police, public works, local governments, Water Users Association, Maharashtra Electricity Distribution Company and the vulnerable population, using telephones, mobile phones, wireless, the internet, etc.

VII. Observations and Recommendations

A. Raising Awareness and Building Capacities

The RTSF & ROS has a huge database that includes historical hydro-meteorological data, river flows and levels, irrigation data, reservoir data, satellite images and other GIS data along with real time data collected through various systems. It also provides tools to effectively analyze this data so that management strategies can be incorporated accordingly. The disaster management framework assumes that all stakeholders need information to act and that there is coordination between them [18]. According the Executive Engineer, Flood Control Cell, Pune, the RTSF & ROS database is available only with the Water Resource Department as there is no formal mechanism in place for data sharing except the website. In a workshop conducted at Yashavantrao Chavan Academy for Developmental Administration (YASHADA), Pune of various Government officials dealing with floods in Krishna-Bhima basin, it was clear that most of the officers are not aware of this system. The study of District Disaster Management Plans of Pune, Satara, and Kolhapur reveals that the RTSF & ROS is neither included neither in the preparedness nor in the Standard Operating Procedure. In many interviews with other important stakeholder like the Indian Meteorological Department, National Disaster Response Force, Indian Institute of Tropical Meteorology, Municipal Corporations, Gram Panchayats, and locals it was revealed that they are also unaware of various services which the system offers. This calls for an immediate action to put a plan in place and devise a sound strategy to create awareness and educate the relevant stakeholders and build their capacities by using the capacity building module and facilitate use of this system regularly. Establishing information sharing policies which include standardization of data its validation, creating standard formats and uniform procedures, protocols, platform, timeframes, authorization, etc. would go a long way in efficient use of the RTSF & ROS. The neighboring state of Karnataka which is also an important stakeholder as its affected by the heavy discharge from the upstream reservoirs needs to be well informed and involved in this capacity building and information sharing exercise.

B. Efficient Early warning System

A key component of disaster risk reduction is an effective early warning system. The RTSF & ROS does have a forecasting and warning system in place. These forecasts are issued daily by the CWC and warnings are issued in case of emergence of flood like situations during monsoon. Generation of actionable information along with implied action is the key to manage disasters. The system is not equipped with a standard classification of information types. The warnings are generic in nature and fail to provide inputs to initiate action at various levels. The district disaster management authorities have standard operating procedures (SOPs) for various departments during floods but these SOPs are not integrated with the information and warnings issued by the RTSF & ROS. Establishing location specific graded warning protocols based on the intensity of floods with details of the actions need to be taken by different stakeholders would improve the efficacy of the system. This may be done in consultation with all the stakeholders including not only government establishment but also the local non-governmental organizations, media, and community leaders. Conducting trainings and mock drills would help in creating a culture of prevention amongst the stakeholders. This would help in ensuring a well-informed response during floods resulting in minimal losses.

C. Fail Proof Communication

Right communication with the right people at the right time plays a crucial role in various phases of disaster management. The RTSF & ROS uses telephones, mobile phones, short messaging service (SMS), wireless, and messengers to communicate with district authorities and other stakeholders involved in flood management. The district emergency operation centers are in constant touch with the dam authorities during monsoon and warnings are issued based on the water released from dams using mobile messaging and telephones but the last mile connectivity is still not ensured. Telephone as well as mobile phone infrastructure is prone to floods and hence, there is an urgent need of putting up a fail proof communication system in place to ensure seamless communication during floods. Direct broadcasting of warning messages using loud speakers placed at prominent places in the village would be a good way to ensure real time communication. Use of local radio channels, HAM radios, at regular intervals to provide relevant information would help the district authorities handle the flood situation better[19].

D. Integration with Development Plan

All the reservoirs in the state are constructed with the objective of water conservation and not with the objective of flood control. As a result of this, the reservoirs and dams are normally used as flood moderators but not as flood controllers. The RTSF & ROS is also developed on this premise. Various models and systems developed therein primarily focus on monitoring the inflow and outflow, and issuing warnings to avoid losses due to flood. A flood is the direct outcome of excessive precipitation but it is also a product of indiscriminate land use, deforestation, and various issues related to planning and development. Cities like Pune, Kolhapur, Karad, and adjoining farm lands in the Krishna and Bhima basin witness floods regularly during the monsoon. Any development is sustainable when disaster mitigation/disaster risk reduction practices are integrated with developmental planning [20]. Instead of using the RTSF & ROS only in controlling and managing the floods during monsoon, its rich database and observations would be used in preparation of development plans for urban as well as rural areas. The data may be used in preparation of land use plans, zoning regulations, and building bye-laws to avoid losses in flooding. Historical observations would help the relevant departments like agriculture and forestry for better watershed management in terms of creating soil and water conservation structures, crop planning, plantations, water use planning, etc. which would help the stakeholders become flood resilient.

Leveraging data, information, and monitoring capacities available with the RTSF & ROS to create risk knowledge along with an innovative early warning mechanism ensuring last mile connectivity would go a long way to achieve the targets set by the Sendai Framework of Action for disaster risk reduction.

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