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Review on Flood Monitoring and Early Warning System

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***Abstract:** A natural disaster which is a sudden event that causes widespread destruction, lots of collateral damage or loss of life, brought about by forces other than the acts of human beings. Disaster can be a type of earthquake, epidemics, extreme temperature, flood, landslides, and storms. Not only in India but also all over word floods are the most common and most destructive natural disaster where lot of mankind and environmental loss is done. According to National Geographic $6 billion damage and 140 people killed due to flood in the united states. This review paper gives you an overall review on the flood monitoring system and Early warning system implemented by people in the different flood prone areas around the world. Also, this paper consists of a comparative table of various technologies used to monitor and to alert at a particular flood prone area.*
***Keywords:** Flood Monitoring, Alert System, WSN, Embedded System, Image Processing*

I. INTRODUCTION

According to Relief and Rehabilitation Department, Gov. of Maharashtra, (2012) flood of 2005 was the most disastrous in the recent history, in which 981 towns and villages were seriously affected. The houses damaged were reported to be 18458 and over 93000 people were evacuated. If we consider the last event occurred in Kerala, where almost 357 people are died, 3.14 lakh people are rescued and 2 lakh people are shifted. Floods are one of the most disaster in India and cause huge losses to lives, properties, livelihood systems, infrastructure and public utilities. India's high risk and vulnerability is highlighted by the fact that 40 million hectares out of a geographical area of 3290 lakh hectares is prone to floods. On an average every year, 75 lakh hectares of land, 1600 lives are lost. Due to floods, the damage caused to crops, houses and public utilities is Rs. 1805 crores.

Flood monitoring system is a way of detecting threatening events in advance. This enables the public to be warned in masses so that action can be taken to reduce the adverse effects of events. Flood monitoring system is an important technology in developing countries, where flooding results in massive loss of life and property. This system can allow detection and assessment of threating events to take place before it hits a community. It is necessary to design or build a system which will monitor the flood prone area and give alert to the people of that area, so that they can shift to a safe place. And due to alert signal people will avoid the travel to these areas. The flood monitoring system and the alert system uses technology like wireless sensor network, embedded system with GSM technology, a camera sensor with image processing technology and the satellite-based monitoring software like GIS etc. In this paper is detected with the different technologies used to monitor and alert the people in flood prone area.

II. LITERATURE REVIEW

J G Natividad and J M Mendez have developed flood monitoring and early warning system using ultra sonic sensor in the northern portion of the province of Isabela, more specifically the municipalities near Cagayan River. The system mainly consists of Arduino, ultrasonic sensors, GSM module, web-monitoring and SMS early warning system. Ultra-sonic sensor is used to measure the water level so that the flood can be monitored. Solar panel operated microcontroller is connected with ultra-sonic sensor and GSM module. All the sensor data is transmitted to the server by using the GSM. The web-based monitoring is done using the PHP and MySQL language. As the alert level increases the notification delivery of the SMS also increase for example in emergency 1 min interval is used.[1] Tibin Mathew Thekkil has developed a real time Wireless sensor network for early flood detection and control monitoring system, designed with a function of real time monitoring with guaranteeing connectivity in low cost. This system consists of CMOS image sensor to capture image for monitoring and Zigbee network and GSM network to transmit the images. Transmitted images are compared with already stored images with the SIFT and BRIEF algorithm and the decision is taken by comparing the ranks. If it alerts danger, alarm will be beeped.[2] Analyn N. Yumang et.al. has developed a standalone flood water level monitoring system for the community in Kahilom Street Pandacan, Manila. The system mainly consists of solar panelled sensor with Arduino Uno, GSM shield. Early warning system is consisting of PVC pipe with three LED and the SMS alert. Mainly three sensors are used to detect the water level, when water touches the first sensor first indictor indicates the water level and so on. As result the average sensing time and sending time is 1.14 Sec and 2 Sec respectively.[3]

Kavi Kumar KHEDO has described the design and deployment of a real time flood monitoring system. This system consists of two sensor nodes knows as MicaZ and SunSPOT. Mainly depth, rainfall and flow sensors are used to monitor flood. GSM technology is used to get connected to internet. Grid to Grid model is used to predict the flood which is based on the river flow path. The RTFMS monitors the flood monitoring parameters in the region of the Rivière du Rempart which is prone to flood.[4]

Hattab Guesmi has proposed a real time model based on wireless sensor network for flash flood and torrents monitoring and the warning system which consists of wireless smart sensors to measure hydrological data. The proposed system determines the expected reaching time, affected zones and danger intensity level based on hydrological and geographic data and initiates the warning system. Author have used LabView simulation tool as simulation platform in which data processing is based on cRIO data acquisition system. The deployed system consists of precipitation sensor, flow velocity sensor, flow level sensor, camera sensor and a temperature sensor connected to a programmable node via a data acquisition board. NI WSN-3212 and WSN-3202 with NI WSN-3212 visual sensors are used. NI-WSN9795 module is installed in cRIO chassis as a gateway. St Venant equations or shallow water equations is used for flood propagation. The proposed model warm communities of the incoming flood to protect people.[5]

Issa Hasan et.al. proposed a new effective method for a continuous contactless water level measurement in critical conditions like flood where other gauging methods fail. Flood monitoring is an important part in today's life. In June 2013, the most expensive disaster recorded in Germany which was 15.2 billion US$. Therefore, a timely monitoring system for the flood monitoring is necessary. By using pressure sensors, floaters, radar sensors and ultrasonic sensor it is possible to monitor water level for the flood monitoring. Dr. Issa Hasan uses an optical water level detection which involves image processing. SEBA Hydrometric GmbH & Co. KG has developed a new gauge for enhanced water Level detection, which is based on the edge detection principle. In which first they select ROI, after that the edge detection technique is applied. At last the Hough transformation is used. This system consists of day and night camera, infrared projector, a white board, a processor unit, a data logger and transmission unit. Using this technology, we can survey, measure and verify the water level data. The surveillance camera is equipped with special, non-visible infrared illumination for night-time measurement and uses an integrated powerful processor to automatically convert data to measurement values. The data and images can be downloaded via remote access. They have tested the developed optical gauge and conventional sensors like radar and pressure sensor at the same location under the different conditions like rain, heavy tropical rain events, snow, fog, day and night time in Germany and Singapore. The accuracy of the camera system was 1.1 %. The results show that root-mean-square error was about 1cm. The application of this technology is within flood protection and monitoring.[6]

Ouychai Intharasombat is reported a flash flood monitoring system by the use of android phone and the Arduino board. In which they have used an echolocation method. An HC-SR04 echolocation sensor is used to report difference between starting time at the transmitter and arrival of the same sound reflex from the object back to the receiver. Along with the LM35 temperature sensor. The prototype model is tested in the Nang Rong waterfall field and laboratory. At the field, the error rate of water level measurement changes as the noise increases. Disadvantage of this system is that, the sound of water flow and falling leaves of trees has significant effect on the echolocation sensor.[7]

Syed Nazmus Sakib reported a flood monitoring system for Bangladesh by using wireless sensor network. Which is based upon neuro-fuzzy controller. WSN uses IEEE 802.15.4 protocol for collecting the information e.g. level of water from river, wind speed, air pressure, rainfall. Proposed flood monitoring system is implemented in Chadpur which is flood prone district of Bangladesh. The information was sent by using Arduino microcontroller and XBee transceiver. A Raspberry pi is used for getting alert and it is storing the data into database. The information is analysed by using neuro-fuzzy controller which is used in Raspberry pi. According to author the results are very accurate as compare to the exiting flood monitoring system.[8]

V. Tejaswitha has proposed a methodology monitoring the water level variation of river for the flood alert using wireless sensor network. This system mainly consists of ARM7 microcontroller, sensors and transceiver. GSM module is used to send the data to the server. Each node present in this system is used to collect the data, processing data and transmission of the data. The alert message is given to responsible person in case of flood state.[9]

Hund Ngoc Do has studied and developed the early flood warning system. In which a cluster of servers were collect the data, process it from the hydrological observation stations in real time and send it to the client computer. They use the water level sensor, rain gauge meter for prediction of warning level and the lag time to calculate the forthcoming flood. They have used ATMEGA processor as microcontroller unit to which water sensor and rain gauge meter data is sent, which is further forwarded to internet using GPRS protocol. For power supply they have used the solar operated battery with different regulated powers. To convert current to voltage a current voltage converter is used. Loud speaker with audio amplifier is present at the residential area for the alert notification. They have tested the system in the laboratory the lag time is 120 minutes at that time the water level get increase. Their

system is divided into three parts depending upon the measured data, for each part system update the duration of getting data and sending the result via SMS and Internet.[10]

Thomas Hies has successful implemented two measurement system in open urban channel in Singapore, from which one is surveillance camera system and other one is radar system. The implemented system consists of 3 mega-pixel camera with router and NAS (Network-Attached Storage)-drive, radar-sensor with 15m range and GSM-GPRS modem. To detect the water level using the captured image they have used the edge detection algorithm in which, selected ROI is processed with edge detection to get edge of the ROI. Hough transformation is used, to isolate and to detect the line from the image. The captured images and videos are downloadable.[11]

In this proposed system the author uses the WSN for collection of average rainfall and flow of water along with level of the various places that is river etc, such weather conditions and raw data information is provided to the respective base station. This system consists of mainly five type of components as data collection, data transmission, data receiving, data processing and information distribution. The current working Indian flood monitoring system is based on the satellite data which is a long process with less data for analysis, so that author uses the WSN for monitoring and transmission. The main objective of this paper is to aware the people about flood and provide high alerts to these areas and saves lives of the river sided mankind. The hydro meteorological department is used to monitor real time environment information used for analysis which helps for the prediction. The methodology of the author is to place the number of nodes at the different flood prone locations. The SMS alert system is used to alert the people from the particular geographical areas as per map. These alert SMS are sent by zig-bee technology.[12] Agoston Restas has proposed a method on the basis of operational and tactical drone application in disaster management. Which is divided into to 4 parts like a time scaled separation of the application, pre-disaster activity, activity immediately after the occurrence of a disaster and the activity after the primary disaster elimination. Author experienced that, managing flood is a very complex and difficult task. It requires continuous monitoring of flood which is very difficult by using the drone. Also, in case of nuclear accident the drone can be a very effective tool to support the disaster management.[13]

J C Pagatpat has proposed a GSM and web-based flood monitoring system. The prototype model consists of float switch for water level detector, inverter, rain gauge, GSM 900 module, and microcontroller development board. The interactive GUI is created to real time monitoring of the water level, which is linked with the google map to specify the area where the sensors are mounted. A sensor is connected with the warning level, as the sensor output triggers the microcontroller, which triggers the connected GSM modem to send the alert SMS to the server. Also the system is designed in such way that the alert signal can post the alert message on the website as well as on the Facebook or Twitter.[14]

Massimo Ancona et.al. has designed a general hardware and software IOT infrastructure system to monitor environmental problem like flood. The gauge shielding architecture is consists of sensor itself with buck converter, boost charger, ultra-low-power wireless communication subsystem like CC3100 for Wi-Fi connection. According to the author M2M is reliable to communicate with the sensors. By using the ultra-low power MCU the minimum power requirement can be fulfilled.[15]

Md. Asraful Islam implemented a Flash Flood Monitoring System in Bangladesh which is based upon the wireless sensor network. By using this system, it is very easy to obtain the information without travel to each monitoring system. The web monitoring system is used for getting the information from sensors. By using liquid level sensor, it is easy to determine presence or absence of liquid. This system is based on mesh networking and it uses two types of protocol like Zigbee and Digimesh. The main objective of this system was to make system with no human presence for administration and maintains. The system takes water level reading at particular time, displays it and if any critical condition is occurring then trigger alarm and sends the message. For sending the message Ozeki Nor SMS gateway is used.[16]

Saurabh Shukla has designed a system to send the real time information of flooding to the welfare authorities so that suitable action can be taken. The designed system consists of sensor network, processing or transmission unit and the server. DRD11A rain sensor is used in which rain intensity has direct impact on the variation of the analog signal. Author has done the trace driven simulation using the OMNET++ simulation tool which operates on the Tiny OS. All the sensor data is collected at the router node, which is further sent through the gateway to the sever. According to the author three states `are created as green, where low risk of flood possible and the sensing period is less as compare to other, yellow state where medium risk is present and the red state where high risk of flood where the algorithm starts the alarm.[17]

Yongjeon has demonstrated a cloud-based Image water level gauge for the measurement of the water level. By the use of this technology it is possible to measure the water level while video surveillance. River Eye hardware is consisting of a video camera, a server, and internet devices. Mainly the river eye system consists of Ip camera with the ADSL/FTTP service, which is used to send images to the image processing server, from which the water level is detected in which character reorganization algorithm and water

level plate are used. Also, the correlation analyses of different images are done to get the water level. The River eye system is tested in the four different field sites such as Ipo, Samsoo, Sujeon and Yuchon. This system can be used practically in the different location to monitor water level for flood monitoring.[18]

Franco Lin proposed a methodology to determine the water level and its surface velocity in real time. Mainly this type of system is developed to provide the safety bridge. For water level detection two high resolution cameras are installed. By using image processing techniques image binarization, water level reorganization and character reorganization are done. Author used edge detection technique is used to identify water line between water gauge and edge of water line. For the measurement of the surface velocity PIV (Practical Image Velocimetry) technology is used.[19]

Edward N. Udo and Etebong B. Isong has developed a flood monitoring and detection system using wireless sensor network for the Nigerian. In which they measure four parameters like rainfall, temperature, water level and humidity to detect the flood situation. In this system they have used a PIC24 microcontroller with the ZIGBBEE radio module for communication. Also, they have used JAVA programming to develop a flood monitoring GUI. In the extreme flood event the system generates alarm and triggers the SMS to the people of the region. The developed system is covers 15 flood prone regions in Uyo metropolis in Akwa Ibom State, Nigeria.[20]

M.S. Baharum has proposed the design of flood monitoring system which consist of flood detector, monitoring display and SMS gateway. In 2010 Malaysian state of Sabah, and the states of Johore, Malacca, Negeri Sembilan and Pahang were flooded due to continuous rain. A is the worst affected country. Therefore, the flood monitoring system is designed, in which the water level variation is measured by sensors which are located in the selected area. This collected data is sent to the control centre, at alert condition SMS is send to the responsible person. The MyFMS system is tested for 24 hours. In the GUI they have shown the monitored data of water level. If the water level is dangerous then the SMS is sent to the authorized person. The system is designed for the ease of use and self-guiding. This system can be upgraded using solar panel.[21]

Yili Chan have proposed the flood monitoring system for the Japan. This work mainly consists of ArcGIS 9.3 (ESRI) and google Earth Pro V5 as a GIS analysis system with a Microsoft Windows. They use DSM to generate contour lines. Designed system provides output via a web-based interface. Output data consist of GIS file KML file and images. According to author KML file is the most useful output data.[22]

Sunkpho has developed a flood monitoring and warning system in Thailand. The developed system is consisting of sensor network, processing and transmitting modules and database and application server. The STAR flow sensor and precipitation sensor by Fischer is used to measure water level and flow level. The processing and transmission consist of GPRS and virtual COM, in which GPRS data unit act like a cable between remote sensors, the application server and MySQL as its relational database. Application servers process the data which is collected from sensors which are accessible by the WAP enabled mobile phones.[23]

Elizabeth Basha et.al. has implemented an Early Warning Flood Detection Systems in Honduras the system mainly consists of 4 operations as sensing, computation, government and office interface, and community interface. To get the information related to the river flooding they measure the river level, rainfall and air temperature at the different nodes which are powered by the solar panels. They used water pressure measurement system to get the river level instead of the water level and ultra-sonic sensors which fails due to corrosion issues and wind effect. The implemented system works at 144 MHz and the 900 MHz band from which for short range communication they have used 900 MHz and for computational nodes 144 MHz band. After experimenting the system in Honduras author have discussed many problems and solutions on it.[24]

III.PRESENT METHOD USED BY GOVERNMENT ORGANIZATION

Presently there are only marking system available which indicate only the levels of water by using the measurement scale. Technical person decides what is the situation of flood and according to it they predict which area is in danger zone. Then, the government officer of that particular district instructs to management people. Then these people start work like arranging schools for accommodation, managing food, boats, etc. In the Kolhapur district for the water measurement at the Rajaram Bandhara they use the manual method. In which, one of the persons go to a particular location at particular time, that time can be in the morning or in the night. That person checks the water level manually using torch light at night. And then he conveys the water level to other person using mobile phone call or any other method. After that, the alert signal is generated to alert the people. In this method, there is lot of risk are present during the heavy rainfall. This method is not safe for the person working for it.

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Figure 2. Rajaram Bandhara Kolhapur district Maharashtra India

IV. PROPOSED METHODOLOGY

The literature review retrieves that there is need of strong electronic system for the flood monitoring. The technology and methodology used by various researchers are mostly depends on the flood prone area present at their particular locations. It is proposed a methodology to monitor the flood prone areas of the Kolhapur district and alert the people of respective area. The proposed methodology for the flood monitoring of the villages present in Kolhapur district consists of a sensor, microcontroller, SMS service and web applications to alert the people. As we can see in the figure (1), all the sensed data can be transmitted to the cloud using the microcontroller to generate the alert signal. This proposed methodology is suitable for the surveyed location named as Rajaram Bandhara at Kolhapur district in Maharashtra India.

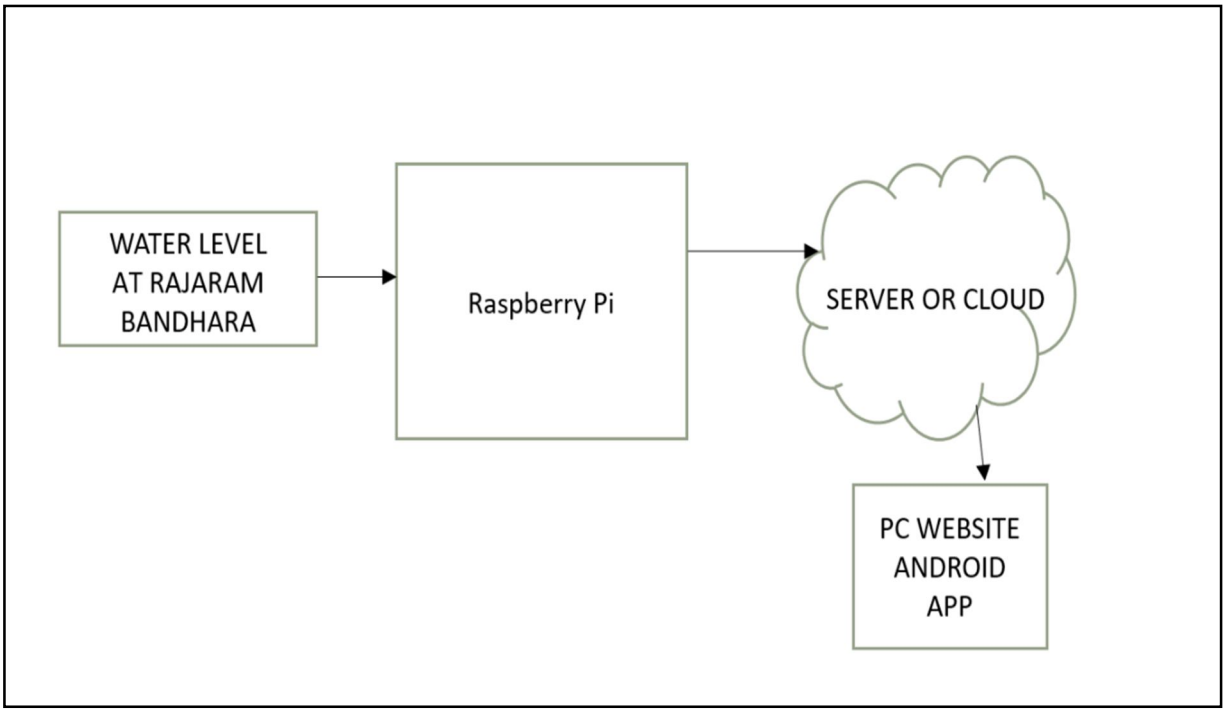

Figure 1. Block Diagram of Proposed Methodology

V. FLOOD PRONE AREAS

Table 1. shows the flood prone are present in the Kolhapur district. All the data present in the Table 1 is collected from the government agency. Total 129 villages are flood prone in the Kolhapur district. In case of the Panchganga river total 22 villages are flood prone in the Kolhapur district.

TABLE I
VILLAGES UNDER THE FLOOD PRONE AREA IN KOLHAPUR DISTRICT

Sr. No.	Taluka	River Name	Village Name	Total Count
1.	Radhanagari	Bhogavati	1.Fejivade 2.Padali 3.Radhanagari 4.Gudal 5.Gudalwadi 6.Aanaje 7.AAvli 8.Ghotwade	11
		Dudhganga	1.Titaye 2.Saravade 3.K.Walave	
2.	Karveer	Bhogavati	1.Haladi 2.Aare 3.Balinge 4.Nagdevwadi 5.Savalewadi 6.Kupire 7.Shindewadi 8.Hanmantwadi	23
		Kumbhi	1.Padali Khu	
		Kasari	1.Nitwade 2.Kerale 3.Kerli 4.Varange	
		Panchganga	1.Chikhali 2.Shingnapur 3. Kolhapur city 4.Vadnage 5.Nigve 6.K.Bawada 7.Bhuye 8.Aamewadi 9.Valiwade 10.Shiye	
3.	Panhala	Kasari	1.Bajarbhogav	11
		Kumbhi	1.Kale 2.Malharpeth 3.Savarde 4.Bhamte 5.Tandulwadi 6.Aavate 7.Gote 8.Aasgav 9.Parkhandale 10.Kharepan	
4.	Gaganbawada	Kumbhi	1.Andur 2.Khokurde 3.Bhagewadi 4.Nivde 5.Salvan 6.Mandukalo Peki Padavalwadi 7.Vetwade	7
5.	Kagal	Dudhganga	1.Vandur 2.Sidha Nerli 3.Sulkud 4.Bamne 5.Kamur 6.Shankarwadi 7.Yekordi	11
		Vedganga	1.Nidori 2.Kurufalo 3.Bange 4.Chikhali	
6.	Shirol	Dudhganga	1.Datwad 2.Danwad	38
		Warana	1.Kavatesar 2.Danoli 3.Ganeshwadi	
		Panchganga	1.Shirala 2.Herwad 3.Palwad 4.Vasrwad 5.Ganeshwadi 6.Takwade 7.Nandni 8.Shirdwad 9.Shirdhon 10.Abdulat 11.Terwad 12.Rendal	
		Krishna	1.Ghalwad 2.Vastwad 3.Ganesgwadi 4.Kothali 5.Akkiwat 6.Shedshal 7.Aalas 8.Dhaanguti 9.Umalwad 10.Kanwad 11.Rajapur 12.Chinchwad 13.Shirti 14.Majarewadi 15.Orwad 16.Arjunwadi 17.Narsinghwadi 18.Kutwad 19.Kavateguland 20.Udagaon 21.Hasur 22.Khidrapur	
7.	Bhudargad	Vedganga	1.Patgoan 2.Shengoan 3.Khanpur	3
8.	Shahuwadi	Warana	1.Sadoli 2.Thergoan	5
		Kadvi	1.Malakapur 2.Pune	
		Kasari	1.Karanjfen	
9.	Hatkangale	Warana	1.Nilewadi 2.Pargaon 3.Chavre 4.Ghunko 5.Kini 6.Bhadole 7.Latode 8.Bhedwade 9.Khochi 10.Vathar TarfUdagaon 11.Kumbhoj 12.Hignggaon	20
		Panchganga	1.Shiroli 2.Engali 3.Ruee 4.Chandur 5.Rangoli 6.Hupari 7.Ichalkaranji 8.Halodi	
			Total	129

VI. CONCLUSIONS

Flood is a most common disaster in the world. After studying the above papers, we can conclude that, the flood monitoring and alert system is way to detect the early event to secure the people of flood prone areas. The implementation and technology of the flood monitoring and alert system is mostly depending on the actual flood prone location. For example, some of the people have used a single camera sensor to monitor the flood and on the other hand some of the people have used the wireless sensor network to cover the large flood prone area. Also, the ultrasonic sensor has the great accuracy but the distortion like wind and sound of water are more sensible to it.

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