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GEOSPATIAL TECHNOLOGY FOR HAZARDS & DISASTERS MANAGEMENT

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Abstract : *Natural disasters such as earthquakes, floods, drought, tropical cyclones, wildfire, tsunami, and landslides affects different parts of the world with varying intensities since past several years. To mitigate disaster losses, more efforts should be applied towards disaster risk management, with a focus on hazard assessment, all of which have an important spatial component. This paper outlines emergency management activities and describe how Geospatial Technology which includes geographic information system (GIS), Global Positioning System (GPS) and Remotesensing(RS) technology plays a critically important role. The use of Geographic Information System (GIS) & Remote Sensing (RS) has become an integrated approach in disaster risk management. Hazard and risk assessment are carried out at various levels, ranging from global to local level with the help of recent advance web based technologies.*

KeyWords:*Geographic Information System (GIS), Global Positioning System (GPS), Remote Sensing (RS), Disaster Management,*

1.INTRODUCTION

Disasters appear are headlines news almost every day. Natural disasters may occur at any time and any location without notice. These disasters pose a threat to structures, people, economic assets and in areas of dense human habitations. Natural disasters have resulted the loss of more than three million lives and affected many more since 1960,. Recent examples are the Uttarakhand landslides & floods in India (2013), Indian Ocean tsunami (2004), the earthquakes in Pakistan (2005), Indonesia (2006), China (2008) and Haiti (2010) , hurricanes in the Caribbean and the USA (2005, 2008). On the other hand there are many serious geomorphologic hazards that have a slow onset such as drought, soil erosion, land degradation, desertification, glacial retreat, sea level rise, loss of biodiversity etc. They may cause much larger impacts on the long run.The recent disaster in Uttarakhand state (2013) is a wakeup call for Decision makers of various authorities.

Disasters are defined ‘a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources’. A disaster is a result from the combination of hazard, vulnerability and insufficient capacity or measures to reduce the potential chances of risk.

Hazard may be defined as “a dangerous condition or event, that threat or have the potential for causing injury to life or damage to property or the environment.” Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, area affected, intensity, duration and frequency.

Vulnerability may be defined as “The extent to which a community, structure, services or geographic area is likely to be damaged or disrupted by the impact of particular hazard, on account of their nature, construction and proximity to hazardousterrains or a disaster prone area.” Vulnerabilities can be categorized into physical and socio-economic vulnerability.

Disasters can be classified in several ways that a natural, human-induced and human-made hazards as shown in Figure1. Natural hazards are natural processes or phenomena in the earth's system (lithosphere, hydrosphere, biosphere or atmosphere) that may constitute a damaging event (e.g. earthquakes, volcanic eruptions, hurricanes). Human-induced hazards are those resulting from modifications of natural processes in the earth's system caused by human intervention which accelerate/aggravate the damage potential (e.g. land degradation, landslides, forest fires).Human-made hazards originate from technological or industrialaccidents, dangerous procedures, infrastructure failures or certain human intervention, which may cause the loss of life or injury, property damage, social and economic disruption orenvironmental degradation (e.g.industrial pollution, nuclear activities and radioactivity, toxic wastes, dam failures; transport, industrial or technological accidents such as explosions, fires and oil spills). Emergency management activities can be grouped into five phases is planning, mitigation, preparedness,

responses and recovery. These are related by time and function to various types of emergencies and disasters.

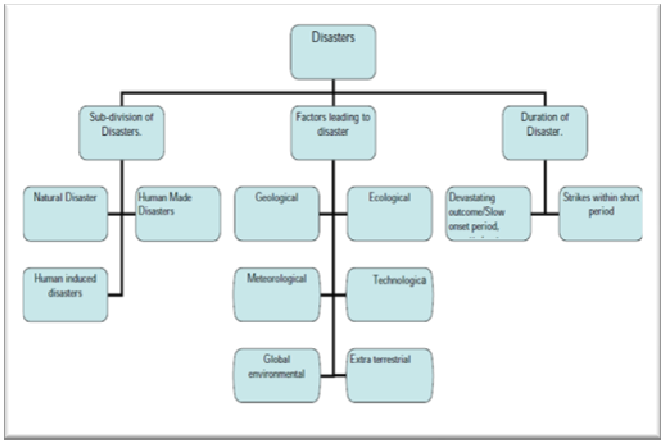

Fig -1: Classification of Disasters

The Indian subcontinent is highly vulnerable to cyclones, droughts, earthquakes and floods. Nearly 59% of the landmass is prone to earthquakes of moderate to very high intensity; over 40 million hectares (12% of land) is prone to floods and river erosion; of the 7,516 km long coastline, close to 5,700 km is prone to cyclones and tsunamis; 68% of the cultivable area is vulnerable to drought and hilly areas are at risk from landslides. Vulnerability to disasters/ emergencies of Chemical, Biological, Radiological and Nuclear (CBRN) origin also exists. Among the 35 total states/ Union Territories in the country, 25 are disaster prone[4].

2. OBJECTIVES

The main objective of this paper is to study existing scenario of disaster management system in Indian contest and propose the integrated approach of web based Geospatial technology for effective disasters management in the event of incidents.

In an emergency, up-to-date information is needed for coordination, communication and efficient decision making. To develop a national resource that describes the advantages and shortcomings of the applications of geospatial technology during disaster.Effective disaster management and demand for rapid utilization of information and data from many sources are very important[3]. The ability to integrate and distribute digital data into spatially explicit forms for rapid assessment and analysis during and after a disaster remains a challenging task. Specialized data, networks, information processing methods and technologies are needed in a highly dynamic situation. The integration of the internet with GIS applications may be applied by means of 3D real-time emergency response, serving maps on the internet for emergency escape routes, mobile GIS and digital video for disaster management[6]. The integration of digital mapping, remote sensing, Global Positioning Systems, satellite imagery, and interactive geographic information systems provides important opportunities for developing useful applications and sharing information and techniques[2]. Geospatial tools and services, including mobile and web-based solutions, have extensively deployed in emergency responses and relief efforts. For instance, mobile mapping solutions ease the work of inspectors and rescuers on the ground. The geospatial web-based platforms have been used for dispatched management and planning, community participatory mapping and reporting[5]. During a disaster geospatial technology integrates diverse and disparate data and makes it accessible. Geospatial technology can provide time critical information to responders and decision makers, and provide powerful visualization in coordinating disaster preparedness, response and recovery efforts. Geospatial technology can used to create maps that included roads and major infrastructure locations to help guide first responders coming from different areas in case of any disaster situation like cyclone , floods, earthquakes, droughts, .

3. METHODOLOGY

This study brings out the approach and methodology for provisioning of an Emergency Response Service (ERS) for the Karnataka State Fire Department. The existing Emergency Response Service (Dial -101) is proposed to be modernized by integrating geospatial technology, which address the needs of the citizens for required aid in times of Fire, Rescue & Disaster distress/emergency.

Karnataka State Fire and Emergency Services Department is the first responder department in the events of fire, rescue and disasters. The uniqueness of this department lies in the fact that, the Fire and Emergency Service personnel knowingly enter the hazardous areas, collapsed buildings, poisonous atmosphere etc, when the people are running away from these premises. They live to the dictum “We Serve to save”.

There are five zones across the state headed by Chief Fire Officer (CFO). Each zone is having 2 to 4 regions headed by Regional Fire Officer (RFO). RFO has control over 3 to 4 districts. Each district has a District Fire Officer (DFO), under whom there are 3 to 8 fire stations. Thus at present there are 187 fire stations and 4 fire protection squads in 152 taluks out of 176 taluks in 30 districts.

The proposed ERS system architecture is based on “Hub” & “Spoke” model, where in the call taking will be centralized at the main controlroom located at the State HQ in Bangalore city. Dispatching will be decentralized at the respective fire station in Bangalore city as well as respective district’s fire station in Karnataka state. The city fire station and districts fire station will be connected through Internet / Intranet.

The proposed solution will be scalar and modular with the provision for including additional district / fire station in the future without change in the system architecture. The

proposed ERS software which includes Call taking Dispatching & Supervisory module will be state of the art and will have capabilities for the integration of Video, Mobile Data Terminals. The proposed solution will also be compatible for integration with IP based interoperable communication switch for seamless exchange of communication using different medium.

The system processes ensure that the event activities of the Responding Units (RU) are tracked throughout the lifecycle of the incident to enforce accountability of all stake holders in managing the incident in most effective and time-bound manner

The incident logging system on the other hand creates a tamperproof record for post event analysis. It includes hi-performance hardware and software that is capable of non-stop operation with minimal downtime.

Existing Setup

A Central Fire Control Room is functioning from the premises of High Grounds Fire Station, located on Sheshadri Road, Bangalore (Figure-2). Separate Call takers seating in one control room to handle fire emergency distress call for Bangalore city & Karnataka state. Toll free 101 telephone facilities are provided to general public, across the state, to summon the services of this department. The general public can contact the department even from coin telephone booths, without putting a coin. There is a PRI line of BSNL with EPABX (Name: Matrix Eternity – GE). Five officials along with telephone line, radio phones & registers to enter the data. This data will be entered in the desktop provided in the media room. With the help of this spread sheet data & prepare their statutory reports in the consolidated format for their day to day activities. A dedicated e-mail system has been introduced for daily and routine transactions. Karnataka state Fire & Emergency Service department is having approx. 550 Nos fire tenders out of 60 fire tenders being used for Bangalore city.

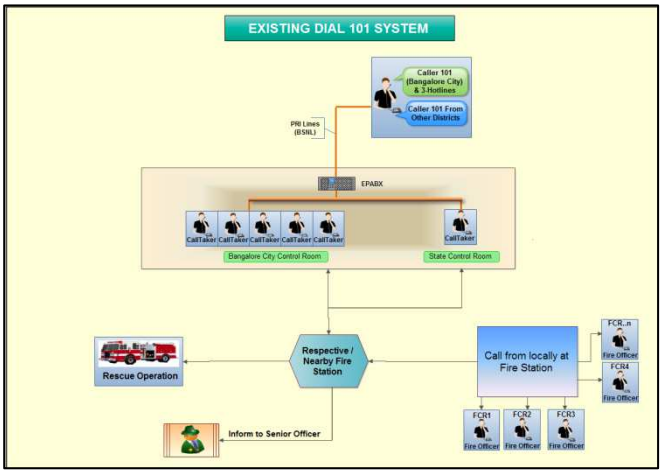

Fig -2: Existing Setup

Bangalore City Workflow:

Central Control Room receives the distress call from the Bangalore city through 101. There are different hot line numbers like 500,550,600 are getting landed to Bangalore control unit. Apart from this each fire station receives the distress call at locally & same are forwarded it to central control room for taking rescue operations. Also this unit is getting connected with hot lines from RBI, KIAL & PCR. The call taker fill the information in the prescribed format, which will be communicated to the concerned officials depends upon the nature of incident for quick response and concerned officer at fire station will dispatch the fire tender at event location. Dispatching willbe done through manual process using telephone and radio communication. There is no log maintained for dispatching process.

Other District Workflow:

Call taker sitting in the CentralFire Control Room receives the distress call from the state through 101. Call taker pick up the call and start the conversation with caller. The caller is calling from outside the Bangalore city then call-taker will transfer the call to concerned state call-taker. State call-taker will fill up the prescribed format, which will be communicated through respective district fire station in the state using telephone or radio communication. Respective districts fire station will take the necessary further action for dispatching the fire tender at incident location. Also State control unit is operated by two officials in different shifts. One stand alone desktop is being used to document their routine work in XLS spread sheet & prepare their statutory reports.

The existing Central Fire Control Room is not designed to cater the multi-hazard response and control system and Multi-tasking. It needs to be up-graded to 'Command and Control System' including 'Mobile Incident Control System', to enable real time monitoring of multi-hazard situations using advanced technology based on Distress Call Response Management System (DCRMS) with GIS/GPS based automatic fire tender tracking system.

Approach & Methodology

The Dial-101 system for the Bangalore city & Karnataka state will be based on the "HUB" & "SPOKE" concept with centralized call taking and decentralized dispatching at each fire station level in the Bangalore city &across the Karnataka state as depicted in Figure-3.

Hub: The HUB will be located in the Central Control Room headquartered in Bangalore city. This control room will have required servers, work stations, existing or new proposed EPABX, PRI line, leased line connectivity etc for

receiving the distress calls from across the Bangalore city as well as other districts of Karnataka state. There will be adequate call taking agents to receive the calls from Bangalore city & Karnataka state.

Spokes: All the fire stations in the Bangalore city &all fire stations in individual district in Karnataka tate will have their individual control room catering for receiving the incident information and taking appropriate action by dispatching the resources available locally. Each fire station will have one web based dispatcher to dispatch the fire tender and provide help to distress call for emergency service. The dispatcher at each fire station will follow the event till its closure.

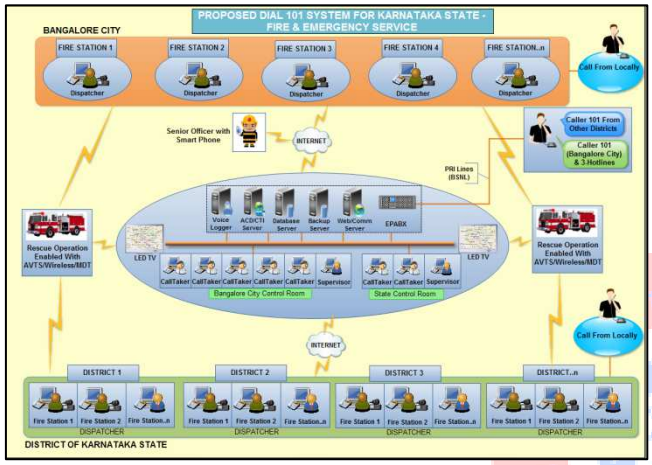

Fig -3: Proposed System

Above solution architecture is representing the overall solution for the state of Karnataka.

4. ROLE OF GIS IN EMERGENCY MANAGEMENT

Most of the data requirements for emergency management are of a spatial nature and can be located on a map. GIS provides a mechanism to centralize and visually display critical information during an emergency. A geographic information system (GIS) can provide that sort of information and tools for the analysis of the spatial data and the representation of the results in spatial format. Management of emergency events is performed in accordance with regulations defined by specific services taking part in described process (fire department, emergency technical services, health care services etc.) Integration of information gathered from all these services will provide needed knowledge required in the process of visual representation and analysis of hazardous events. This enables timely notification (using GIS interface) of current status of all relevant parameters.

Decision makers of authorities can pinpoint hazards and begin to evaluate the consequences of potential emergencies or disasters. When hazards (earthquake faults, fire hazard areas, flood zones, shoreline exposure, etc.) are viewed with other map data (streets, pipelines, buildings, residential areas, power lines, storage facilities, etc.), emergency management officials can begin to formulate mitigation, preparedness, response, and possible recovery needs. Before an effective emergency management program can be implemented, thorough analysis and planning must be done. GIS facilitates this process by allowing planners to view the appropriate combinations of spatial data through computer-generated maps.

During emergencies, GIS enables emergency managers to quickly access relevant data about an affected area. However, the problem is that the needed spatial and non-spatial data is usually geographically dispersed and stored in heterogeneous databases. Types of data usually needed in emergency management can be classified as follows [1]:

• Data on the emergency phenomena (for example earthquakes, landslides, floods,), their location, frequency, magnitude and so on.

• Data on the environment in which the disastrous events might take place: topography, geology, geomorphology, soils, hydrology, land use, vegetation and so on.

• Data on assets that might be destroyed if the event takes place: infrastructure, settlements, population, socioeconomic data and so on.

In order to make all the mentioned data readily available when it is needed and in the form that it is most easily consumed it is needed to solve two basic problems. These are semantic heterogeneity and geographic distribution of the relevant data.

5. INFORMATIONCOMMUNICATION TECHNOLOGY (ICT) SUPPORT

The basic communications and IT support requirements for disaster management correspond to the following three levels:

- Decision makers and disaster managers at all levels.
- Real time dissemination of advance warnings and information to the concerned authorities at various levels and threatened community. For dissemination of advance warning and information through broadcasting mediums such as television and radio shall be used significantly as it has higher geographical reach. For coastal and hilly regions, network of meteorological department may be used.
- Last mile connectivity at the disaster site for control and conduct of rescue and relief operations.

Communication and sharing of upto-date information using state-of the art IT infrastructure remain at the heart of effective implementation of the disaster management strategy. Reliable, up-to-date and faster sharing of geo-spatial information acquired from the field or the affected

areas is a pre-requisite for effective implementation of disaster management strategies. Efforts should be made for setting up IT infrastructures consisting of required IT processes, architecture and skills for quick up-gradation and updation of data sets from the Panchayati Raj Institutions or the Urban Local Bodies. A National Emergency Communication Network, involving the contemporary space and terrestrial-based technologies in a highly synergistic configuration and with considerable redundancy, will be developed. This Network will ensure real time dissemination of warnings and information up to the affected community and local authorities.

6. HOW DOES THE TECHNOLOGY WORK?

The objectives of Disaster management system used to provide emergency services such as police, fire and medical for the general public in case of emergency situation. The salient features of the system are its detailed database which contains information about all the hospitals, police stations and fire stations. If any disaster or accident occurs in these localities, according to the users requirement the nearest service will be provided. It can also provide the shortest route to reach the service provider location. The system provides additional functionalities of locating hospitals based on the facilities required, Police stations and Fire stations based on the area of incident. Search for any emergency services based on the user's requirement & location specific. The working methodology of the system is as shown in Figure-4. The disaster management system incorporated with the following system requirement such as collection of satellite data, creating the road network map, Add all the layers on the map and create shape file for various services, location of emergency service providers using GPS and their details, creating the GIS database, creating web services, developing tools for the integration of various services, testing and validation on the communication ability, spatial query processing and response generation.

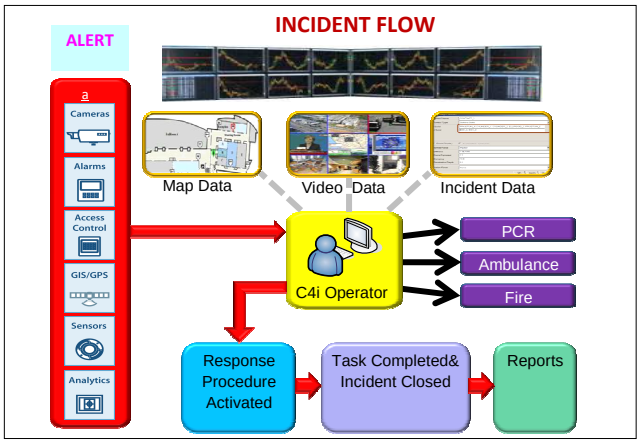

Fig-4: Web based GIS for multi-hazard risk assessment

Simply put, geospatial technology by using computers to create digital maps. These maps can be created to display most any application on the earth - from calls for service to frequency of accidents at an intersection to displaying the quickest route to an incident. Unlike traditional paper maps, though, geospatial technology can be used to create real time maps that can be produced, distributed, and easily updated with just a few mouse clicks! Once the data is mapped it is available for comparison and analysis to see how you perform over time.

7. CONCLUSIONS

The significance of this paper is in creating unique hazard management methodology and developing the software (based on the mentioned methodology) which can be applied in disasters management. The unique methodological approach, which provide data recording, manipulation and evaluation of hazards progress, risk estimation, possibility of preventive analysis and preventing hazards in order to decrease loss as effect of hazards (in the organizations and in nature), will be defined applying multidisciplinary research in proposed system implementation. Multidisciplinary approach is based on the new information technologies (GIS, web services, semantic integration), expert's knowledge about structure and processes in the disaster management system, hazard emerging and possible effects on living environment, as also combine the knowledge of expert's working in different domains. This will improve the process of hazards and disaster management. The proposed models and services will be specialized for application in involved organizations and public services. So, the solution efficiency provided by proposed system will be especially valuable for local community and local authorities.

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