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Role Of Global Information System In Disaster Management: The Need Of The Hour

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Abstract-The prime concern during any disaster is the availability of the spatial information, and the dissemination of this information to all concerned. GIS has emerged as a very important tool for effective planning, communication, and training in various stages of the disaster management cycle. GIS plays a key role in this aspect by providing cost-effective information at various stages of the disaster life cycle, with a much wider reach. This article covers the concept of how Internet-based GIS can be used as a effective tool for disaster management, in various stages of the disaster management life cycle focusing on the Indian perspective with a SWOT analysis (strengths, limitations, opportunities and the risks) of using the Internet-based GIS for disaster management.
Keywords–Cost effective information, Disaster life cycle Internet based GIS, SWOT analysis.

I. INTRODUCTION:

Death and destructions are fall out of all disasters, but as mankind expands and develops the planet, we are likely to enhance not only our knowledge but also our vulnerability to these disasters. Man's tampering with our fragile ecological system has brought with it serious environmental threats in the form of global warming and changes in the climatic pattern.

All these aspects lead to natural disasters. The other aspects of our development and industrialization are leading to what we call human induced disasters. These could be either industrial disasters, transportation disasters or CBRNE (Chemical, Biological, Radiological, Nuclear and Explosive) disasters. Be it Bhopal gas tragedy, Chernobyl incident or Sarin gas attack in a Tokyo subway or Mumbai bomb blasts or more recent terrorist escapades of 26/11, all these account for major disasters in today's urban complexes which are bursting due to population explosion.

The multiplying nature of disasters increases the number of stake-holders and make disaster management a challenge. In 2005, with the passing of the Disaster Management Act and the establishment of NDMA, there has a paradigm shift in the approach to disaster management. The new policy replaces the old reactive approach with a more proactive approach concentrating on prevention, preparedness and mitigation aspects in line with the national policy humanitarian logistics.

There are several terminologies used in disaster management like[1]:

A. Emergency

Emergency is a deviation from planned or expected behaviour or a course of events that endangers or adversely affects people, property, or the environment.

B. Disaster

Disasters are characterized by the scope of an emergency. An emergency becomes a disaster when it exceeds the capability of the local resources to manage it. Disasters often result in great damage, loss, or destruction.

C. Risk

Risk is the potential or likelihood of an emergency to occur. For example, the risk of damage to a structure from an earthquake is high if it is built on or adjacent to an active earthquake fault. The risk of damage to a structure where no earthquake fault existsis low.

D. Hazard

Hazard refers generally to physical characteristics that may cause an emergency. For example, earthquake faults, active volcanoes, flood zones, and highly flammable brush fields are all hazards.

GIS is a powerful tool for Disaster Management. GIS in Disaster Management Mitigation of natural disaster management can be successful only when detailed knowledge is obtained about the expected frequency, character, and magnitude of hazard events in an area. Natural disasters have shown a drastic increase in magnitude and frequency in the last decades. It is also imperative that there be a dramatic increase in technical

capabilities to mitigate them. Access to information is crucial for the effective management of disasters. All those who are concerned with managing disasters necessarily have the need to access timely and accurate information. Normally, a considerable amount of money is spent on just finding the relevant information. This happens because the information is stored redundantly in several places and in several formats. Maps and spatial information are important components of the overall information in case of any disaster event (flood, earthquake, cyclone, landslide, wildfire, famine, and so forth). Hence mapping and spatial information acquisition becomes vital for any disaster management effort. In general, GIS can be used in any part of the disaster management cycle; namely disaster preparedness, response, recovery and mitigation. But one important need for any disaster management effort is to have the spatial information accessible to a larger group of people, in a fast, easy and cost-effective manner. The use of GIS on the web can help a lot in achieving these objectives.

Figure 1.GIS Mapping

II. OBJECTIVE

Accessibility and dissemination of timely and accurate information.

III. FUNCTIONAL REQUIREMENTS

a) System provides information regarding various disasters like its type, its group, location etc.

b) It will also give information about killed and affected zone nearby.

c) System records the timings of disaster and gives assessment on particular disaster.

d) Manager can view the map and relevant information about disaster [2].

IV. CONCEPTUAL FRAMEWORK

Table 1: GIS framework [3]

INPUT	PROCESS	OUTPUT
Field Data	Data Capture	Maps
Maps	Storage	Reports
Remote Sensing	Validation	Table & Charts
Tabular Data	Analysis	Models

In this system input can be taken as tabular data or maps on basis of that GIS can analyse & visualize and generates important information as maps, reports, statistics etc.

IV. THE EMERGING ROLE OF WORLD WIDE WEB IN DISASTER MANAGEMENT

The World Wide Web is an effective tool for communication. It provides a platform for people across the world to exchange ideas, knowledge and technology. It brings together people with common interests irrespective of their geographical location and the distance separating them. In its role as an effective tool for communication, it can be invaluable for disaster management. The usage will only increase as the Web reaches out to every nook and corner of the world and more and more people become online. All the countries are recognizing the importance of developing an information infrastructure capable of sustaining state of the art technology for use at the time of disasters. Furthermore, there is a move towards globalization of disaster networks to provide speedy assistance to every disaster victim, irrespective of the national boundary and geographical location. This globalization will have far-reaching impacts, and hopefully, the catastrophic events will become less disastrous with the increasing use of WWW and networks. It is already being used for effective information management in various other areas, and it has started being used for managing disasters as well. But the use of GIS on Internet, which could have powerful implications for disaster management, is yet to be fully explored. Integration of GIS and the WWW will

lead to an enormous increase of the usage and accessibility of spatial data. In today's context, the usage of GIS is normally restricted to a community of trained experts. Making GIS available through the World Wide Web could make this technology accessible for many more people. For the large group of GIS inexperienced users on the Net the handling of a WebGIS needs to be much simpler to use than existing stand-alone GIS.

V. THE POTENTIAL OF INTERNET GIS FOR EFFECTIVE DISASTER MANAGEMENT

Thousands of web sites provide images and maps of the earth, but this information remains underutilized for disaster management. Consider a disaster management application to seamlessly access, view and exploit the vast, diverse and widely distributed geospatial data holdings on the Web. Having been isolated earlier in desktop applications and back-office servers, geospatial technologies are now undergoing a transformation to become better suited for the Web. Geo-enabled web services can be integrated in space and time for better decision-making, learning, and research in the disaster management field. These services will provide more than maps, but maps are an important beginning for any disaster management effort.

Effective disaster management requires assimilation and dissemination of pre-planned, historical and real-time information to many sources. This information must be relayed and understood in the shortest amount of time possible to carry out the required activities. Police agencies must communicate with government departments, which in turn notify emergency medical professionals and paramilitary forces. The channels of communication must be open at all times. Moreover, all this "talking" must occur within extremely hostile conditions; earthquakes, tornadoes, hurricanes, floods and other events are time sensitive and don't leave much room for delay or faulty communications.

Enter Internet GIS, which can be used to plan for, respond to and recover from emergency situations, providing personnel the most accurate information when its most needed - constantly. In other words, Internet GIS gives the emergency management professionals the ability to assemble large amounts of public information about their community, and analyze and use the information in an efficient, intelligent manner. GIS data organization format displays graphic data in a format, which is easy to understand. The system's database may show boundaries, topography, road network, utility and supply lines and other features vital to disaster planning. Linked with an extensive database that provides capabilities for real-time command and control, Internet GIS transforms disaster response into regular emergency management exercise.

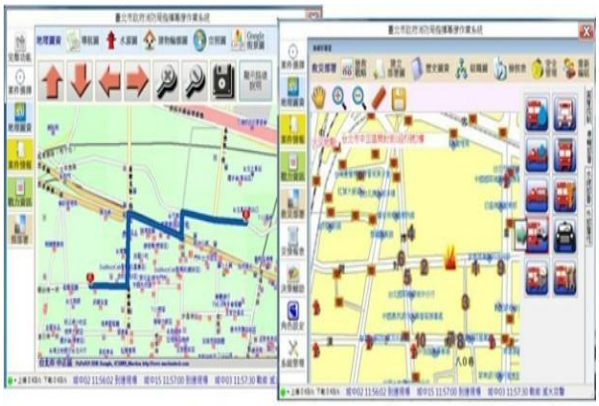

Figure 2. Incident Command System

VI. STAGES IN THE DISASTER MANAGEMENT LIFECYCLE

There are five important phases of disaster management: disaster prevention, disaster mitigation, disaster preparedness, emergency management, and disaster recovery. Of these, disaster prevention, disaster mitigation, and disaster preparedness constitute the pre-disaster planning phase. Pre-disaster planning is the process of preparing in advance, to meet a future disaster. Disaster prevention is the action taken to eliminate or avoid harmful natural phenomena and their effects. Disaster mitigation is the action that deals with reducing human suffering and property loss. Disaster preparedness encompasses those actions, which are taken to limit the impact of natural phenomena by structuring response and establishing a mechanism for effecting a quick and orderly reaction. Emergency management covers responding to disasters by various organizations, providing many services that need to be mobilized on a moment's notice, and functioning for an indeterminate period in a coordinated manner under stressful and difficult circumstances, and may be demobilized after the emergency has abated. The ability of an agency, or a group of agencies, to manage emergencies, rather than just react to crises, is critically dependent on the availability and flow of real time and archived information from monitoring systems, thematic databases, and decision support systems that are linked through national networks. Disaster recovery is the last phase of disaster management and is concerned with providing relief after the disaster has struck. As disasters (earthquakes,floods and hurricane) are usually spatial events so all phasesof disaster management depend on data from a variety of sources.So, Geographical Information System as a tool to collect, store,analyse and display large amount of spatially Information layers, supports all aspects of disaster management[4].

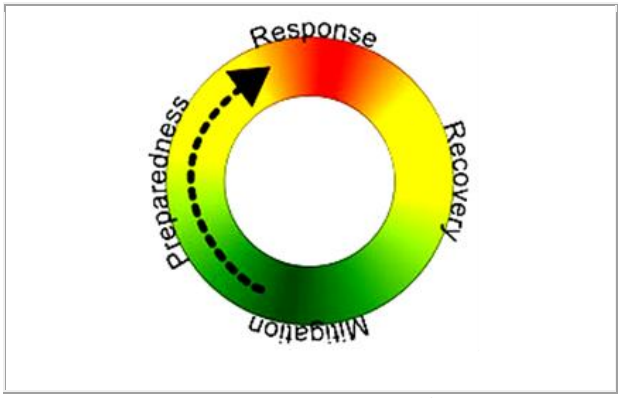

Fig 3: Disaster Management Life Cycle

VII. ROLE OF INTERNET BASED GIS IN PHASES OF DISASTER MANAGEMENT

The Internet based GIS can be used in many ways for effective disaster management. Also, the applications of the Internet-based GIS can range over the entire disaster management cycle. Integration of the GIS and the Internet technology can be used to significantly increase the usage and accessibility of the spatial data, which is a key requirement before, during and after any disaster. The application can function very much like a "Whiteboard in the Sky" in which a number of agencies can share event information via the Internet. The approach allows several agencies operating on different technology platforms and using different communication channels to use the Internet to collaborate while managing the natural disasters like cyclones, earthquakes etc. It provides a platform for exchanging ideas, knowledge and the latest update during the event of any disaster, which is of utmost importance. Also, Internet-based workflow management can be integrated with the GIS data & applications to manage the multiple activities of the various agencies involved in the disaster management. In a community's daily operations, a GIS can collect, maintain and store vital map information related to infrastructure, cadastre, street networks and land use, all of which is displayed graphically and supported with associated database records. The information is managed by different agencies and used in daily workflows. When information is collected across an entire community and shared among the responsible entities, a disaster management network is created.

The pre-disaster preparedness activities like risk identification, risk assessment, awareness and warning are aimed at those actions, which are taken to limit the impact of a natural phenomenon by structuring response, and for establishing a mechanism for ensuring a quick and orderly reaction. This can be organized very efficiently through the use of GIS on Internet, for example by making available the risk maps, as well as the "do's and don'ts" on the Internet. It can also allow carrying out some basic "what-if" scenario analyses. An Internet GIS based emergency management network can help in ensuring effective public safety. As city, state and national governments deploy Internet based GIS technology, there will be demand for a comprehensive, integrated approach to managing the entire range of spatial, as well as non-spatial data used in carrying out various governmental responsibilities and services. Data exchange at local, regional, city, state and national levels can be a continuous and cohesive process, resulting in better management and control of resources.

Table 3: GIS in Disaster Phases

Prediction and Warning • Monitoring • Forecasting • Early warning • Scenario identification	**Prevention & Mitigation** • Hazard Analysis • Simulation & Modelling • Vulnerability analysis • Risk assessment • Risk mapping • Structural assessment • Awareness campaign • Training and capacity building	**Preparedness** • Resource Inventory • Stockpiling • Logistic planning • Evacuation planning • Communication planning • Needs assessment
Response • Situation analysis • Crisis maps • Infrastructure communication • Evacuation and shelters • Dispatching of resource • Early damage assessment	**Relief** • Search & rescue • Rubble and debris removed • Logistics • Delivery of relief supplies • Prioritising actions	**Recovery Rehabilitation** • Spatial planning • Infrastructure • Housing • Livelihood • Social Security • Transport • Water • Communication • Housing • Agriculture

During the disaster, real time monitoring and evacuation/rescue needs immediate attention. The latest information can be made available through Internet giving a detailed picture of the event tracking, forecast of the affected region, the evacuation plan, and the position / movement of various agencies like military and NGOs. The strengths of each channel of communication and the challenges faced in using them are summarized in Table 3.

Table 3: Comparison of Different Communication Channels Used in Disaster Warning

Channel	Benefits	Challenges
Radio & Television	Widespread	Takes time to get warnings Limited use at night.
Telephone fixed and mobiles	Messages delivered quickly	Problems of authenticity Does not reach non-users Congestion
SMS	Quick Messages can be sent to groups	Congestion Does not reach non-users Local language problems
Cell broadcasting	No congestion Can address a group simultaneously	Does not reach non users Local language problems
Satellite radio	Highly reachability	Cannot be used to educated masses Only good for specific points
Internet/Email	Interactive Multiple sources can be checked for accuracy of information	Not widespread
Amateur/Community radio	Excellent for rural, poor and remote	Not widespread

The post-disaster activities like relief, relocation, recovery, damage assessment, repair and reconstruction dealing with providing food and shelter to the disaster victims, restoring normal conditions and providing financial and technical assistance to rebuild can be effectively coordinated by using Internet-based GIS as a very powerful tool. This includes making the latest information available regarding the spatial coordinates of the affected people and sources of providing relief and rescue, the regional extent of the calamity, and the geo-positioning of the "lifelines" like water supply and transportation network etc.

Mapping of GIS is a vital tool for health care analysis of disaster preparedness [5] A mapping system achieves its most dramatic results in conjunction with logistics management applications. A logistics management system can include many functions, but it's basically a communications network among a community and its disaster management and response personnel. Such a system should also use radios and telephones effectively. Disaster management professionals work in a hectic and demanding world, with little time for hesitation and even less time for error. For them, a system that can dispatch complete, intelligent logistics situation maps, and update them at short intervals, could be a major tool for ensuring public safety. The use of Internet GIS can provide an effective solution for this purpose. With the help of Internet GIS, the latest information on routes, affected areas, the demographics of the affected area can be posted on the web using this all the agencies can coordinate their efforts in a more effective manner. Remote sensing as a landscape epidemiologic tool can be used in various health care disasters like malaria.[6]. Further Mathematical Computer Modelling along with GIS is going to be an important tool for predicting disasters in future [7].

VIII. THE INDIAN PERSPECTIVE

With technology becoming more user-friendly, and cost-effective in India, Internet GIS can be now used for the management of disasters in India as well. For example, it can be used effectively in the event of
any disaster for providing the first hand information about the extent of damage, the areas affected and to direct the rescue and relief operations. Taking the case of a hypothetical earthquake event, the first information that would be needed, is the location of the epicentre and the extent of the worst affected areas. The Internet GIS through its applications would enable the emergency managers to have a map of the affected area along with other statistics such as number of houses, the population, using which an estimation of the causalities and damage can also be done. The information stored online becomes widely accessible to the concerned agencies and people, and the various control rooms can be established having interconnections through a wide area network. This Internet based GIS system can also help in accessing the various map layers such as the transportation network- the network of rails and roads, the communication network and the status of infrastructure- physical as well as social. The information on the various road links, which get cut off due to the catastrophic event, can be updated on the net so that a clear picture of the available links can be provided, and the relief operations can be directed accordingly. Also, the information about the nearest hospital and other emergency services such as

fire stations can be provided. The worst affected areas can be marked and all those regions where relief has already been provided can be shown in the maps. This enables the relief agencies to regulate their activities effectively. Apart from the applications during the disaster and post disaster, an Internet based GIS system can serve as a vital media for providing information related to disaster and in pre-disaster phase to provide preparedness measures.
Overall, the use of Internet GIS has tremendous scope in the Indian context, considering the vulnerability of the country to disasters of various types, the extensive use of spatial data in disaster management, and the growing popularity of Internet. It has great potential, and has been put to good use in the other developed and developing countries as well. At the same time, use of Internet GIS in the Indian circumstances also poses some challenges, which need to be overcome in the coming years.

IX. SWOT ANALYSIS

A SWOT (Strength, Weaknesses, Opportunities and Threats) analysis of the scope and application of the Internet GIS in Indian scenario has been presented here.

Table 4: SWOT Analysis for the use of Internet GIS technology

Strengths	**Weaknesses**
Cost Effective Wider Reach Simple to use Facilitates Cooperative effort Faster Dissemination of information	The existing dependency of Internet access on normal communication network, may not work during disasters Sophisticated analysis and modelling not possible at this stage Higher bandwidth requirement Mobile internet still not popular in India
Opportunities	**Threats (Risks)**
Use of new communication and networking technology for better connectivity The reach can be extended to handheld devices Higher bandwidth availability in the future can make real time analysis possible With new technologycost of Internet GIS can be brought down	A comprehensive Internet based GIS application could be difficult to develop, and slower than a similar desktop GIS application (Solution: Only put minimal functionality on the web, and use it only as a supplementary tool) The high initial cost of developing such application (Solutions: Shared funding by various players involved in the disaster management cycle)

X. CONCLUSION

The opportunities created by Internet based spatial applications are immense, and are being universally accepted. However, apart from bandwidth constraints, the technology involved in web applications offers some unique challenges for application developers. Despite all its constraints Internet GIS, can be immensely helpful in managing disasters. In a vast and disaster-prone country like India, Internet GIS can be very much used for coordinating and managing the spatial data display and analysis needs of the various agencies involved in the various stages of the disaster management cycle, for any natural peril, and for any region. A Web-based GIS helps to estimate the extent and size of damages, just after the particular disaster. It also, helps the managers to rapidly response to various disasters. This takes a lot of advantages to the managers by decreasing the cost and response time to make better decision during and just after the disasters.
GIS is well suited for disaster management as it can produce maps with structured data and hence the information is well organized; and GIS information is easy to update and maintain current files. However, the knowledge of the above is not all. Efficient management of potential risks can only be accomplished if emergency managers are aware of the extent of the possible effects of disasters. Tools can be developed to act as a decision support system for emergency management agencies, through the use of a geographic information system (GIS). Because each cyclic phase in emergency management is related to where people, places, and things are spatially located, GIS can be a valuable tool for analysis purposes throughout each cycle. Disasters can affect us anytime, and even if the window to predict their happening is open, nature can take its course without an alarm and hence it should be our priority to be aware of the dangers that such disasters may inflict. Usage of GIS in natural as well as man-made emergencies is a requirement that all governments need to take seriously. Although there are obstacles to the implementation of GIS in every disaster affected area, effective planning can be used to reduce the number of people, places and the extent of disaster that is affected by the calamity

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