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Utility of Geographic Information System in Disaster Management

Dr. Pawan

Assistant Professor, Department of Geography, FGM Government College, Adampur, Hisar

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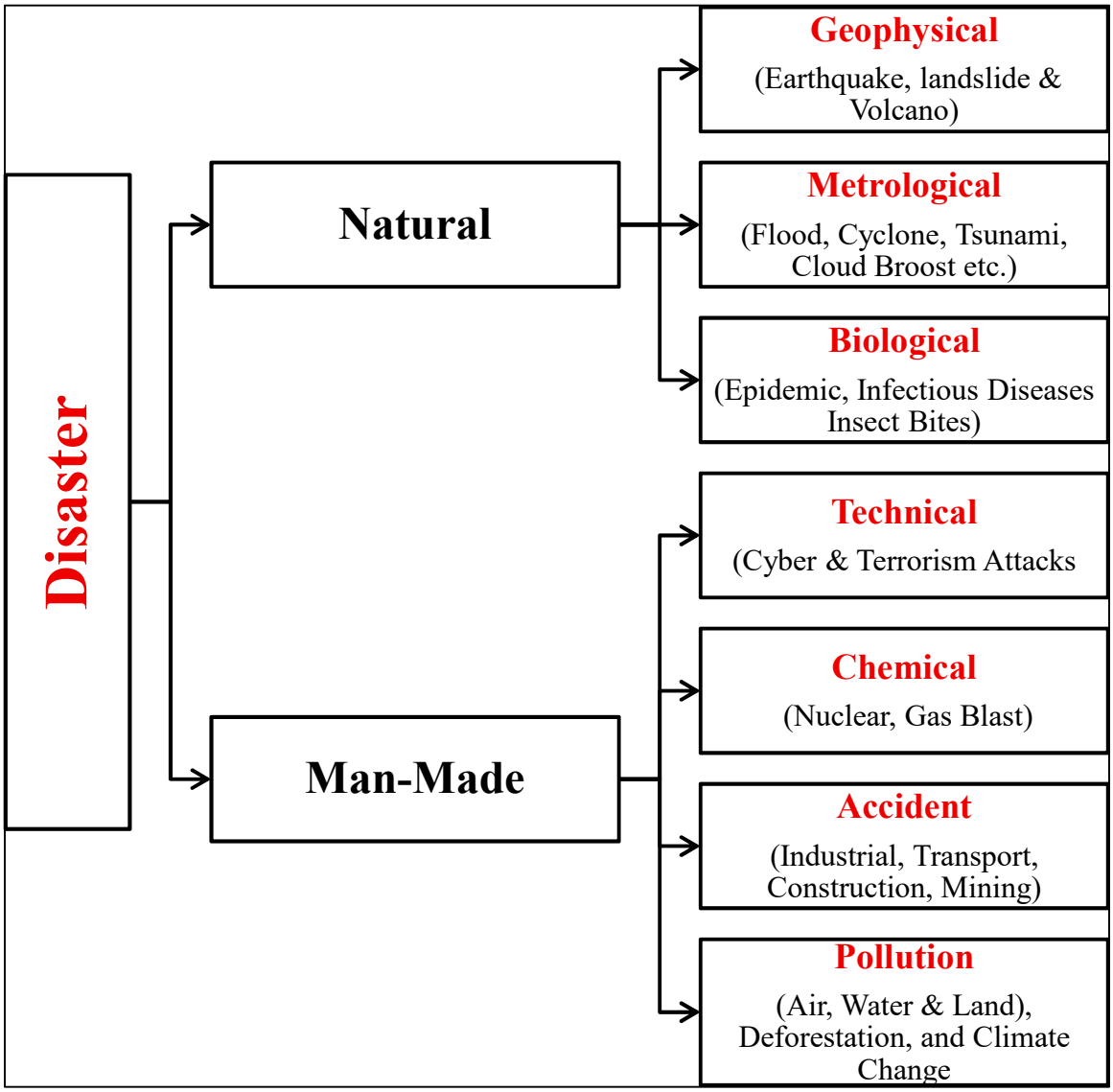
ABSTRACT

The present paper attempts to understand the utility of Geographical Information System in disaster management, which is a multi-dimensional, complex and burning global issue involving natural and non-natural disasters. In-depth literature investigation of the issue reveals that spatial technology has the potential to scientifically assess, control and rehabilitate various disasters. Over the years, the potential of GIS platform has been of dominant utility in disaster risk reduction, thereby attracting the attention of spatial planners. To explore the present issue, various phases of disaster management - forecasting, mitigation, preparedness, rapid response, rehabilitation and reconstruction have been covered and an attempt is made to examine the processes of Geographical Information System which provides scientific basis for policy formulation, regional planning, resource management and community participation for disaster prone areas. This paper recognizes the importance of Geographical Information System for quick and accurate results of future disaster management and demands its compulsory inclusion in school and college syllabus along with development of necessary infrastructure for its use so that disaster risk reduction can be done through skill development and youth participation.

Introduction: GIS, based on spatial and non-spatial data base, is a computing technology whose capability is evident from the quick collection, accurate analysis and presentation of data. Some scientists (Goodchild, 1992 and Burrough, 1986) considered the meaning of GIS as “decision support system”.

There is a paramount demand for GIS planning in the supply of various aspects of global sustainable development, because the definition of GIS is not limited to a tool for mapping the subject matter but it is a strong platform for quick and scientific solutions for environmental management, urban planning and disaster risk reduction. Understanding the multi-purpose capabilities of GIS requires considering it as much more than just a mapping tool **(Mennecke E. S. & Crossland D. M. 1996)**. He studied some fundamental scientific issues and research related to GIS data, in which he studied two topics in depth. The first topic included scale dependence of spatial data and analysis of spatial data, the second topic included transformation and flow of data and information. For further development of GIS, he suggested the need to focus on research to establish a better interface between data and map presentation, management and user **(Frank et al, 1991)**. He discussed the development of GIS for use in educational research, and said that mapping techniques have not only helped in diversifying the presentation of subjects but also broadened students' perspectives **(Yuan X, 2020)**.



He identified the importance of GIS and investigated its utility in rescue operations in affected areas despite limited resources available for investigation. The data was investigated using quantitative psychological and cartographic methods **(Jan et al, 2023)**. The earth's cultural heritage is seen to be vulnerable to increasing natural disasters, their preservation in the contemporary scenario is a global challenge. He clarified that in order to save the cultural heritage; there is a need to implement an effective planning that can reduce the risk of natural disasters. GIS platform is considered to be an effective technology in this process, which provides special references and strategies for dealing with the risk of disasters in a hierarchical manner and for the protection and management of sensitive areas **(Guanyu et al, 2024)**. They examined the applications of GIS in economic development, changes in living standards and environmental improvement. GIS is a strong pillar in balancing the environment with increasing technology and economic growth **(Wang K, 2019)**. In their study, they identified the usefulness of GIS

in identifying industry locations. They also investigated the usefulness of GIS techniques in determining the location of solar power, a major source of renewable energy **(Gokhan et al, 2024)**. He investigated the utility of GIS in determining vulnerable areas affected by floods, one of the major natural disasters, and found that GIS is an accurate and important technique in demarcating flood affected areas **(Wael et al, 2024)**. In his study, he examined the main factors responsible for fire emergencies and their solutions and found that the nature of every emergency is different and the rescue process is determined accordingly. In the rescue process, GIS is considered an important tool for comprehensive analysis of spatial data and accurate and quick results in the rescue process of the risk area **(Hyun et al, 2024)**.

Objective:

- To investigate the utility of Geographical Information System in Disaster Management.

Methodology: Firstly, the types of disasters were identified and classified using flow charts. A detailed study of the different types of disasters was done in the historical and contemporary scenario. For this detailed study, secondary data as well as research journals, magazines, articles, disaster reports were used. The utility of GIS in various stages of disaster management was examined using the software.

Result and Discussion:

First Stage: Pre-Disaster (Forecasting and Preparedness) vs GIS: Among the various stages of disaster management, pre-disaster is an important stage in which GIS technology plays a role in the following levels;

a) **Hazard Zonation Mapping:** Mapping technology of GIS makes its dominant impact in disaster management clear as it provides spatial analysis of natural (earthquake, flood, cyclone etc.) and human disasters in vulnerable areas. National Remote Sensing Center working under ISRO of India has mapped disaster related vulnerable areas which makes the utility of GIS beneficial in risk reduction plans.

b) **Risk Assessment:** GIS technology integrates attribute and spatial data (land use & land cover) to analyse risk. A report released by UNDRR (2019) showed that GIS analysis has been shown to be 30-40 percent more accurate in risk assessment of sensitive areas.

c) **Early Warning System:** GIS mapping of meteorological information enables prediction of disasters, which is effective in risk reduction. GIS based forecasting of the super cyclone that originated in the Bay of Bengal in 1999 significantly reduced the risk magnitude.

d) **Community Awareness:** A 2020 World Bank study found that GIS-based maps make community efforts more effective in risk reduction in vulnerable areas.

e) **Resources & Infrastructure Planning:** GIS technology makes it possible to pre-demarcate essential infrastructure facilities such as medical facilities, exit points, relief camps etc. during a disaster. In 2005, the United States, realizing the severity of Hurricane Katrina, implemented mandatory evacuation route planning based on GIS mechanisms.

Second Stage: During Disaster (Response Stage) vs GIS: Emergency decision making process of Geographical Information System is most important in disaster management, GIS technology helps in disaster management at following levels;

a) **Real-time monitoring and Assessment:** GIS is capable of quickly analysing imagery and sensor data provided by remote satellites, which aids in emergency decision making, and also identifies more vulnerable areas through spatial assessment, allowing rescue teams to provide prompt response.

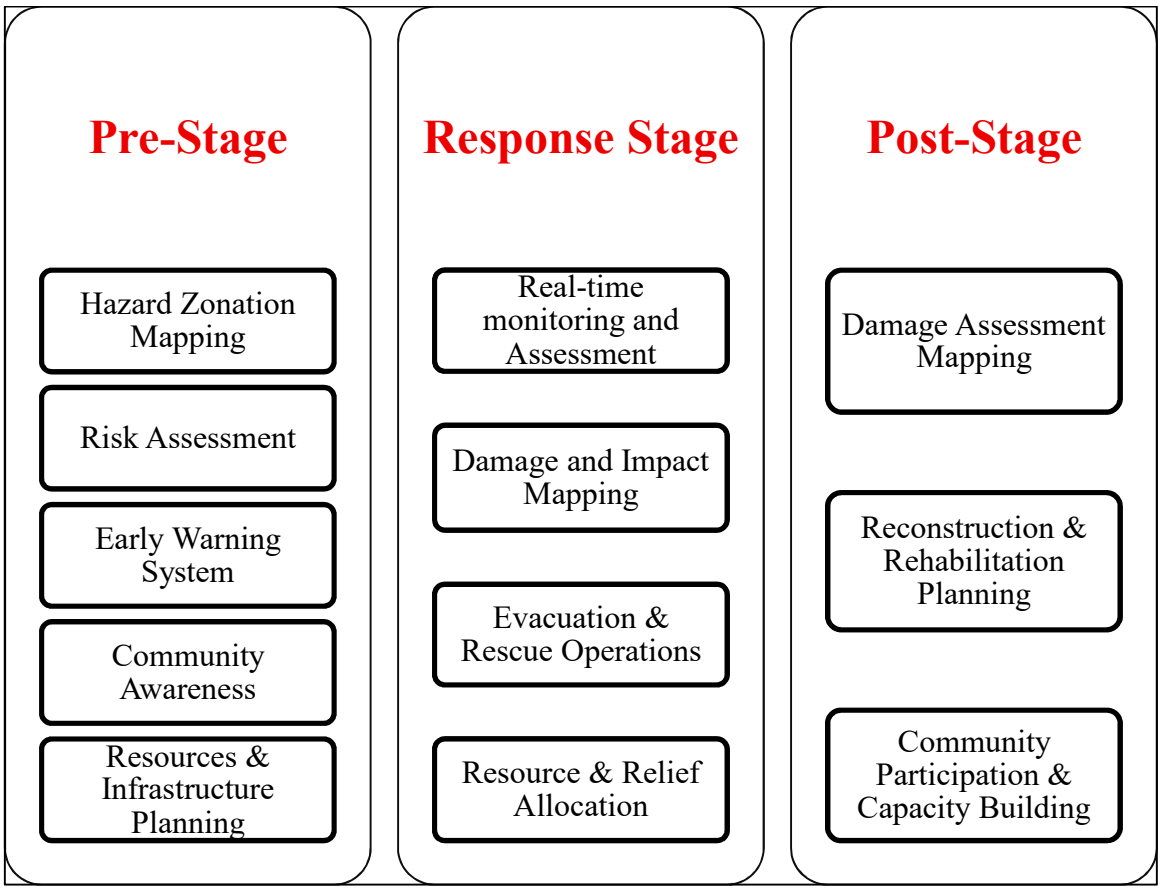
b) **Damage and Impact Mapping:** GIS allows rapid mapping of infrastructure damage, which is helpful in delivering medical and other relief supplies to vulnerable areas.

c) **Evacuation & Rescue Operations:** The most important task during a disaster is to rescue the victims on time and to move the disaster victims from vulnerable areas to safer places. GIS technology helps in taking accurate decisions on the following steps by using spatial and real-time information;

   i. Identifying safe evacuation routes that are the least crowded and reach the safe place in the shortest time so that quick services can be provided.

   ii. GIS demarcates temporary shelters in the affected area such as community centre, schools, hospitals, panchayat bhawan, dharmshala, etc. so that the affected people can stay at safe places.

   iii. Optimization of rescue operations is an important step in GIS technology that classifies the affected area into risk levels and identifies which part is most vulnerable and how much population is at risk there, so that priority can be determined and assistance can be provided to the most vulnerable areas.



d) **Resource & Relief Allocation:** GIS technology not only involves rescuing the affected people and taking them to safe places but also providing first aid and other medicines, food items, clean water, clothes as per weather and disaster in sensitive areas. For this, GIS:

   i. Estimates the requirements of the affected area, how much relief material is needed, in which the socio-economic condition of the affected area is also assessed.

   ii. GIS also helps in making the distribution of relief material easier, it selects safe routes by marking the obstructed routes so that relief material can reach quickly by saving time.

   iii. GIS also monitors and tracks the relief material so that it can be assessed which and how much material has been sent where, how much is left, how much more is required. This not only brings transparency but also facilitates the proper distribution of relief material and helps in reaching help to every needy person.

Last Stage: Post-Disaster Recovery & Rehabilitation vs GIS: The task of this stage is not only to orient the affected people towards normal life but also to build capacity to deal with disasters in future.

a) **Damage Assessment Mapping:** The most important task after the disaster is to assess the damage of the affected area and spatial analysis is done by GIS and Remote Sensing in a rapid and scientific way.

b) **Reconstruction & Rehabilitation Planning:** This stage helps planners to select priorities as to in which area reconstruction should be started first. In infrastructure development, GIS presents disaster-resistant design which minimizes the risk from disasters like flood, earthquake and cyclone.

c) **Community Participation & Capacity Building:** Participatory GIS (PGIS) involves community power in the reconstruction phase which helps in understanding local needs as well as land use planning.

Conclusion: Disaster management is a multifaceted and multi-phase process, and Geographic Information Systems have established themselves as a powerful technological tool for mitigating disasters. The GIS approach is not only scientific but also enables quick decisions and more transparent service allocation. In the pre-disaster phase, GIS assesses risk using spatial data and satellite imagery of sensitive areas, acting as a bridge for spatial planners and enabling accurate forecasting. In the second phase, GIS technology, capable of making quick decisions, acts as a lifesaver during a disaster as it analyses remote sensing and satellite imagery, which are sources of real-time data, and provides accurate guidance. In the final phase, rehabilitation and reconstruction, the priority of damaged areas is accurately determined, enabling equitable and effective use of resources. As an indispensable technology, its use in modern disaster management is not an option but a necessity.

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