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An in-Depth Assessment of Flood Susceptibility Using Geo-Informatics – A Detailed Review

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Abstract

In recent years, the world has faced many disasters, but the effects of floods have received considerable focus due to their harmful consequences. More than half of the global destruction and damage from floods takes place in Asia, leading to loss of life, infrastructure damage, and community panic. The main goal is to improve the understanding of flood hazard management by conducting flood vulnerability assessments. Vulnerability is central to analyzing and evaluating floods. Scholars have suggested various strategies for understanding vulnerability assessment and the role of Geographic Information Systems (GIS) in evaluating flood risks. GIS helps monitor disaster patterns and mitigate risks. This research systematically reviews methodologies for assessing floods and their vulnerabilities using GIS. In this context, vulnerability serves as the primary concept in the analysis and evaluation of floods. Numerous scholars have proposed various approaches and techniques to comprehend vulnerability assessment and the role of geographic information systems in evaluating flood vulnerability and its related risks. Geographic information systems monitor and forecast disaster trends while also helping to reduce risks and damages. This research provides a systematic review of the methodologies employed to assess floods and their vulnerabilities through the integration of geographic information systems.

Keywords: Geographic Information Systems (GIS), flood risk assessment, disaster management, hazard mapping, climate change impacts

INTRODUCTION

Floods represent the most prevalent natural disasters that India encounters nearly every year, albeit in varying intensities. The destruction of property and the suffering inflicted by the obliteration of essential civic amenities due to floods are immense. Additionally, floods result in significant loss of human lives and a considerable number of livestock, alongside the profound hardships experienced by a large segment of the population. Year after year, floods constitute a major disaster impacting numerous countries worldwide. This natural occurrence is unavoidable, manifesting periodically in all river systems and natural drainage networks, which not only devastate lives, natural resources, and the environment but also lead to economic and health-related losses. The continuously growing population, along with the amalgamation of properties in urbanized regions, has heightened the flooding risk [1–5]. As the population continues to rise, the effects of flooding are expected to escalate in the future. By the year 2030, the impact on individuals residing within 100 kilometers of the coastline is anticipated to be considerably more pronounced. Recent flooding events have prompted numerous inquiries regarding climate change and the influence of human activities on the global climate. It is also projected that population growth will contribute to an increase in the frequency of flooding

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incidents. As a result of population expansion, valuable land has been transformed into water-resistant zones, leading to erosion, natural runoff, and an increase in flooding. In recent years, the average financial loss due to flooding has escalated to approximately fifty billion USD annually. Research has indicated that between the years 2010, 2013, 2014, 2015, 2017, 2018, and 2019, there has been a rise in the occurrence of flood disasters [6–10].

Flood disasters affected a significant number of individuals in the years 2000, 2007, 2014, and 2015. From 2010–2020, nearly 3.6 billion people were affected by flooding, which represents 56 percent of the global population. During the period of 2010–2020, approximately 820,000 individuals in both South and North America experienced the impacts of flood hazards. In the least developed nations, flood disasters resulted in catastrophic conditions that led to severe human suffering, extensive damage to infrastructure, threats to life, and hindered economic growth. In the last ten years, countries – such as Bangladesh, Mozambique, Germany, India, China, Malaysia, and the United States – have contributed to catastrophic situations and extensive harm to both lives and property [11–16]. The devastation is not confined to developing nations; it also has a profound effect on the world's most urbanized and affluent countries. Between 1988–2000, Central America and Asia experienced significant destruction and economic losses amounting to USD 3.64 trillion because of both natural and anthropogenic disasters. Urban areas with high population densities are more susceptible to flooding, and the consequences vary depending on the assets involved. In the years 1977 and 1978, India experienced its highest recorded fatalities, with an average population of 3.2 billion. In contrast, the year 2001 saw significant damage to public services.

The underlying factors contributing to human devastation include the emergence of various diseases in the river, deterioration of agricultural productivity, and damage to infrastructure, all of which are fundamental causes of fluvial vulnerability. Furthermore, disasters accounted for 80 percent of fatalities among women and infants, highlighting their increased susceptibility. The level of vulnerability is not uniform and varies geographically, with the degree of correlation having a direct impact on the implementation of policies [17–20]. Therefore, it is crucial to identify regions that are susceptible to flooding to effectively address community vulnerability – an essential component of the community's capacity to manage the repercussions of floods. Both operation and strategic analysis and assessment of floods require spatial and hydrological modeling, risk assessment, and model estimation. Time analysis is fundamental in this case, projecting, forecasting, and decision-making with real-time risk analysis. Nowadays, the world is facing both natural and manmade disasters. To alleviate the impact of a flood, the discussion on coping with the rapid environmental changes needs a systematic vulnerability technique to reduce the flood risk.

A more effective instrument for assessing flood vulnerability and spatial planning is developed through the integration of traditional methods with spatial decision bridges. GIS-based evaluations of flood vulnerability are advantageous for extensive regions, although hydrodynamic models can delve into more specific elements of flood dynamics [21–25]. The linear methodologies exhibit considerable limitations compared to parametric approaches in flood vulnerability assessment. Nevertheless, the amalgamation of these two methodologies will provide a comprehensive understanding of vulnerability scenarios within a given area. These researchers analyzed flood assessment in a region as a function of probability and consequences. Models based on machine learning have shown less pronounced flood vulnerability in the Haraz watershed of Iran, utilizing hybrid and ensemble techniques. They emphasized that the selection of appropriate model parameters could be effectively applied to integrate flood susceptibility. Monitoring accountability regarding floods is a crucial component of flood risk assessment.

RESULTS AND DISCUSSIONS

For many years, vulnerability has been recognized as a significant issue among researchers, particularly concerning natural disasters. Numerous authors have broadly defined the concept of vulnerability. In terms of social insecurity, the broader concept of vulnerability was examined. Flooding is more closely linked to land conversion and climate change. However, numerous studies have emphasized the impact of climate change, particularly regarding the onset of floods and the resulting vulnerability in specific regions. Various statistical methods, both quantitative and qualitative, along with geospatial analysis, have addressed the challenges posed by flood hazards in the assessment of flood vulnerability. The vulnerability is an evaluation of an individual's or a group's susceptibility to the effects of a threat and their capacity to bounce back from those effects. Vulnerability is the potential to damage a receptor. The importance of perceiving certain vulnerability assessments as the conclusion of any evaluation, while others are viewed as the central focus, and still others as the initial stage. Moreover, the concept of vulnerability to provide an economic perspective on flood vulnerability. The concept of vulnerability, highlighting the need to explore it and its associated conditions. They gathered various concepts and models to help understand vulnerability. Over time, circumstances affecting vulnerable populations have changed. Methodologies – like risk-hazard (RH) and hydrological models – are key in assessing flood vulnerability, contributing to the understanding of vulnerability since the 1980s.

Based on a review of various studies, a decision model was used to elucidate how individuals understand hazards, marking the initial effort to define vulnerability. The model was referred to as vulnerability. It employed GIS to evaluate the flood susceptibility of the Bodva River basin located in eastern Slovakia, utilizing a range of parameters. These indicators are analyzed and integrated into the GIS to categorize the study area into one of four vulnerability zones: acceptable, moderate, unpleasant, and unacceptable. The keywords identified in the review implied that there is a scarcity of studies focusing on geospatial methods in the analysis of flood risk. Furthermore, it suggested that utilizing GIS predictions for assessing flood vulnerability could yield greater advantages. Key factors influencing flood susceptibility have been identified concerning coping capabilities and resistance. A comprehensive examination of numerous studies related to flooding and vulnerability revealed that various flood analyses have been employed for many years. Nevertheless, the introduction of remote sensing (RS) and GIS technology in flood assessment has significantly enhanced the relevance of flood analysis.

CONCLUSIONS

Since the 2000s, research has examined various flood strategies and vulnerability assessments. Over 150 papers by leading researchers were analyzed to create a coherent study of methodologies. Flood susceptibility evaluation was illustrated through keyword graphics outlining methods and datasets related to flood studies. The review highlighted recent models in flood vulnerability evaluation and compiled a database of commonly used metrics and techniques. Findings showed a strong interest in flash floods, tidal flooding, and urban flooding. Many scholars are using GIS, statistical analyses, RS, and programming to assess flood susceptibility. This research focuses on historical and contemporary data and spatial variables to map global vulnerability. Key limitations include the variety of methodologies, specific vulnerability types, the number of references, and the tendency to focus primarily on flooding.

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