Recent Trends and Techniques in Landslide Hazard Assessment

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Abstract

Landslides are a serious concern in steep terrain where severe storms are common. The magnitude of landslide risk depends not only on storms and the physical characteristics of the land, but human activities, especially agricultural practices, are important. An essential stage in the management of landslide risk and hazard is landslide hazard assessment. Landslide Hazard Zone (LHZ) choice processes include intuitive, half size, Quantification, Probability and Multi-criteria approaches. Among the various techniques used traditionally, Multivariate approaches, albeit with limitations, to assess landslide risk at a regional scale Very feasible and cost effective. Over the past two decades, landslide research has expanded use of the sophisticated tools of remote sensing and geographic information systems (GIS) to study landslide hazards.

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Introduction

Landslides, one of the most common natural disasters, cost the economy heavily in direct and indirect costs of property loss every year. A landslide is described as the movement of rocks, debris, or soil down a slope caused by external factors such as heavy rains, earthquakes, and changes in water levels, storm surges, or rapidly eroding streams. A sudden rise in shear stress or a fall in the shear strength of the constituents of a slope [1]. Geologists, engineers, members of society, and local governments throughout the world have all developed a keen interest in assessing landslide risk and hazard in recent years [2]. Understanding, predicting and controlling the risk associated with landslides is still an empirical task given the current state of knowledge. Geology, structural geology, engineering geology, hydrology, hydrology, geophysics, geotechnology and civil engineering. Risk assessment can be analysed at multiple spatial and temporal scales according to the objective [3]. Advances in geospatial technology will help reduce losses as it emerges as a powerful technique for mapping the landslide hazard zone. Different researchers use different methods to assess landslide risk. But, there is no universally accepted method to effectively assess landslide risk [4]. The usage of such GIS-based technologies has demonstrated that the majority of tasks can be completed quickly and affordably. It is anticipated that improved GIS modules, faster computers, and more advanced data capture/visualization equipment will eventually be affordable and capable of doing broad and advanced spectrum spatial analysis.

Landslide Hazard

A major geological hazard that harms the natural and social environment is landslides. Although they are a part of nature, landslides may be dangerous, lead to fatalities, and harm both man-made and natural infrastructure. Numerous publications have varied definitions for the word "landslide rick." [5]. Landslides are considered hazards only when they impact society or the environment [6]. The chance of a pretty stable condition abruptly changing, or the likelihood that an event would cause harm in a certain location and over a specific amount of time, is how physicists describe a natural hazard [7]. Landslides are a minor but significant part of the range of risks that civilization is experiencing on a global scale. If given the option, individuals would choose to rely on their safety by residing in locations on Earth that are free from the risk of landslides [8].

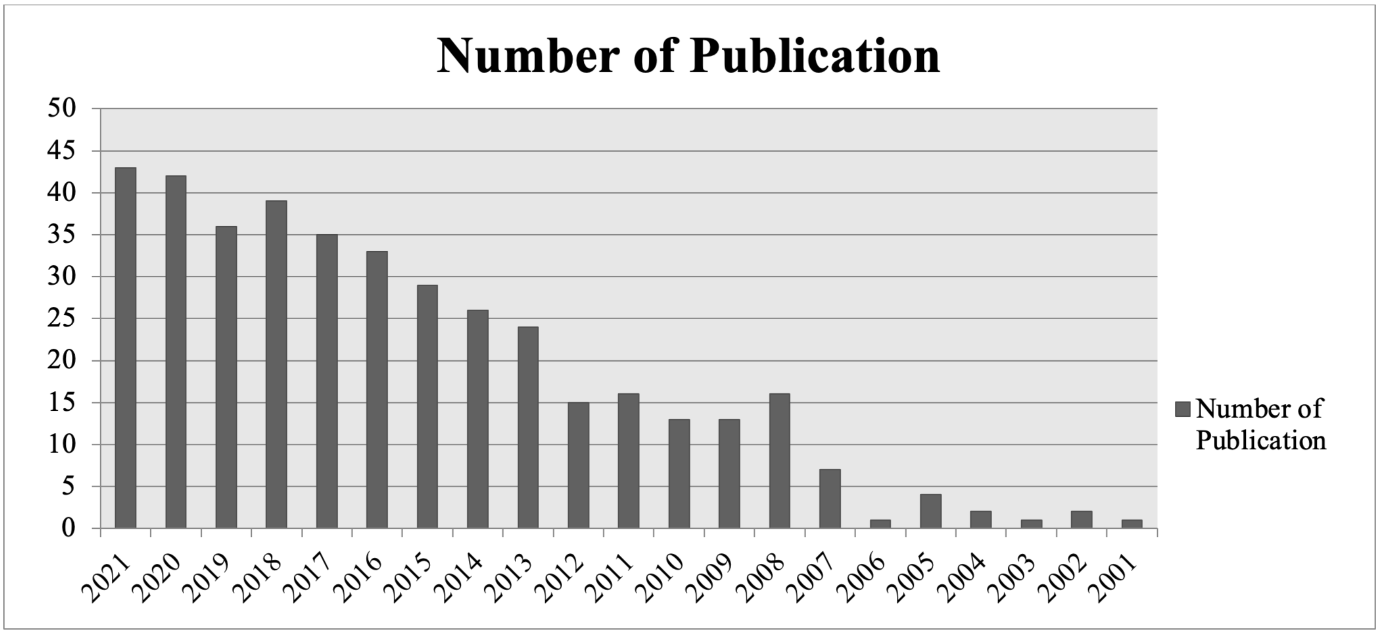

Figure 1. No of publication on Landslide hazard in India

In early twenty first century publication on landslide hazard in India ware very rare. In recent years number of publications on landslide hazard in India are steadily increasing. The temporal frequency of triggering events and the danger of landslides are tightly related. When analysing the danger of landslides in a changing environment, the time component is crucial [9]. Landslides are frequently caused by earthquakes. Landslides and other types of ground collapses brought on by earthquakes can occasionally inflict more damage than damage directly caused by seismic activity and fault rupture [10]. A high number of landslides and related damage typically come from triggering events like moderate to severe earthquakes or extremely intense rainfall; maps showing a predicted strong seismic event or documented heavy rainfall event show a worst-case scenario. An area's deterioration can be attributed to a history of unstable obesity [11]. Since rainfall-induced landslides have recently resulted in considerable property damage and fatalities, it is crucial to evaluate the slopes' post-failure behaviour [12]. The initial impact of an earthquake increases as the earthquake's magnitude rises. Levelling happens quickly, but landslide losses rise more quickly. [60].

Land hazard zonation

Extrinsic factors, such as rainfall and human activity, and intrinsic factors, such as geological conditions and landslide structures, are two groups that affect the risk of landslides [13]. As a result of industrial and recreational expansion, infrastructure development, disruption of communication arteries and population growth across the country, many countries [14]. Related to vulnerability, risk and frequency assessments more on the list of difficulties a large amount of expert input is required to develop risk and subsequent risk zoning [15]. It is often desirable to estimate order to compare risk locations and calculate the resulting risk. Their sensitivity all affects the risk zone. These components should be evaluated for new developments. Risk maps for regions with current development should be updated often since hazards might alter when new development occurs [48]. Frequently occurring catastrophic natural events including earthquakes, large-scale movements, floods, and avalanches are linked to mountain building. These processes frequently conflict with one another, creating a variety of natural risks for infrastructure and mountain residents [16]. Maps showing landslide-prone locations are necessary for officials and decision-makers to take these areas into account when making development plans and/or putting suitable risk reduction measures in place. Many organisations and scientific societies have provided standards for creating landslide hazard maps to help with risk management choices. There are numerous techniques for determining landslide susceptibility, risk, and hazard [17]. An important to refer the unfavourable outcomes or loss of life and property as a result of the occurrence of landslides. Landslide risk assessments, necessary for planning a variety of development activities in the area [18].

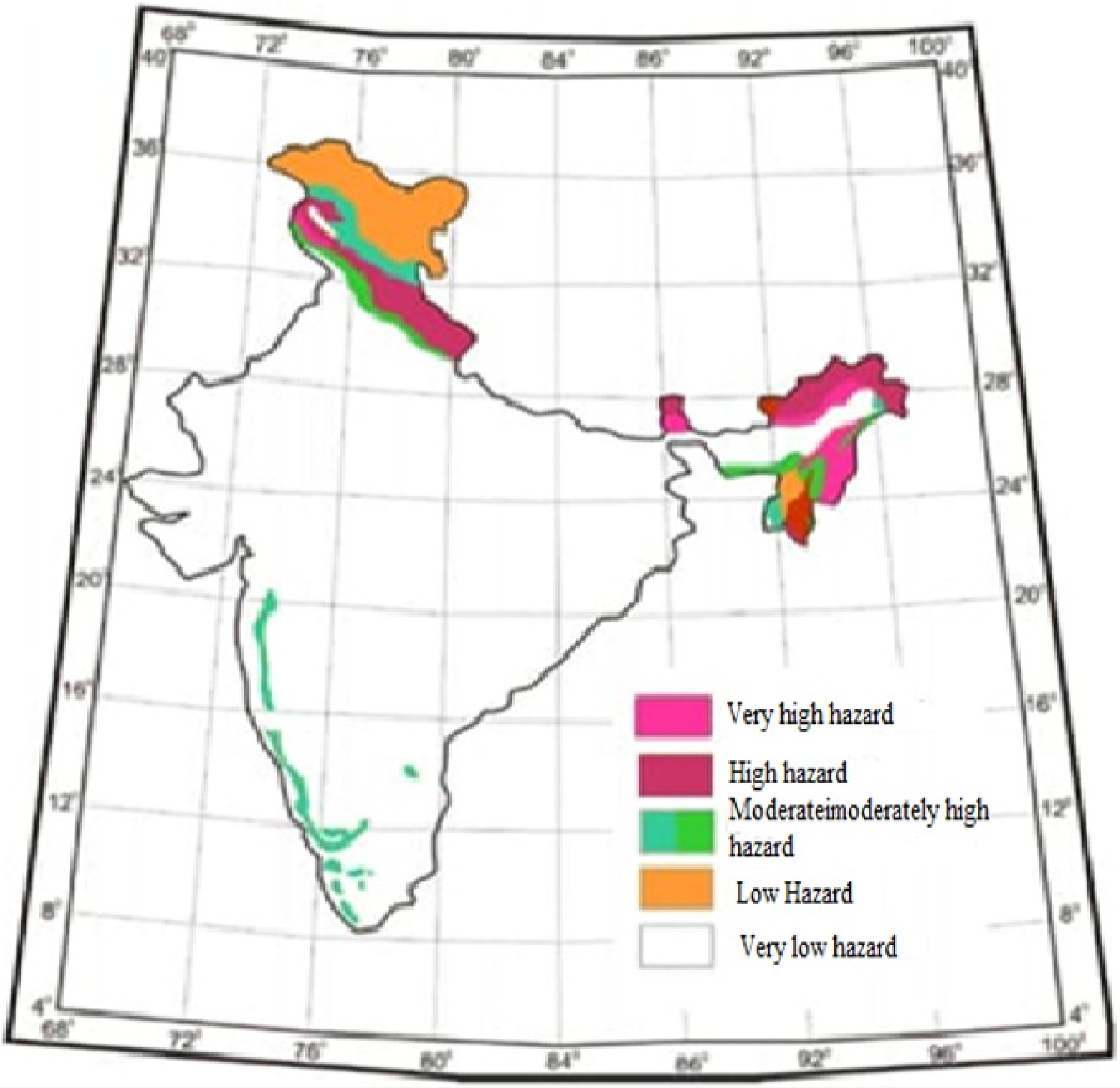

Figure 2. Map showing land slid hard zones in India

Figure 2 shows the appearance of landslide hazard in India. In India most of the places have very low landslide hazard. In the Himalayan regions landslide hazard zones are high. Detection and monitoring of frequently inaccessible landslides and associated phenomena in the Himalayas owing to the mountainous terrain and inadequate infrastructure development, is the first step in achieving this. High resolution earth monitoring capabilities from orbiting satellites. Identification of landslide-prone regions by landslide hazard zoning, which refers to the partition of land into homogenous units and classifies them in accordance with the likelihood that landslides would occur, is a second step in this direction [19]. To get knowledge of the geographical and temporal frequency of landslides in order to produce an accurate map of landslide risk and hazard forecasting in a specific region. The fullest possible representation in time and place [20]. Landslide Hazard Zone Map, Based on the projected fit of factors that create instability Divides the ground surface into zones of different stability. Using a macro-zonal methodology, the Land Hazard Zone Mapping technology displays the likelihood of landslide dangers. Maps of land hazard zones are often created at scales between 1:25,000 and 1:50,000. Desk research and field investigations are the two basic parts of LHZ mapping [21]. A landslide risk reduction strategy is made easier by a map of the Landslide Hazard Zone (LHZ). Based on geo environmental elements conducive to landslides locally, it gives previous information about landslide prone zones. Based on the parallel that future landslides are anticipated in areas with the same geo environmental circumstances as previous and present landslide locations, the LHZ assumption was developed [42].

Land hazard assessment

A thorough understanding of landslide processes, probable failure modes, and features of landslide debris runout should serve as the foundation for any evaluation of landslide risk. Otherwise, it is impossible to provide a trustworthy assessment of landslide risk to guide risk management choices [22]. National, regional, and local authorities must participate in land slide risk reduction at different levels, frequently with the assistance of decision-makers from the scientific community [23]. To reduce potential harm, it is obvious that we need to better understand geological. In the past three decades, geoscientists have made a lot of efforts to create express implicit goal better managing slope instability [24]. Assessments of the risk of landslides in metropolises and urban regions have significant social effects. The chosen areas are populated thickly, and the predicted landslide damages are substantial. [25].

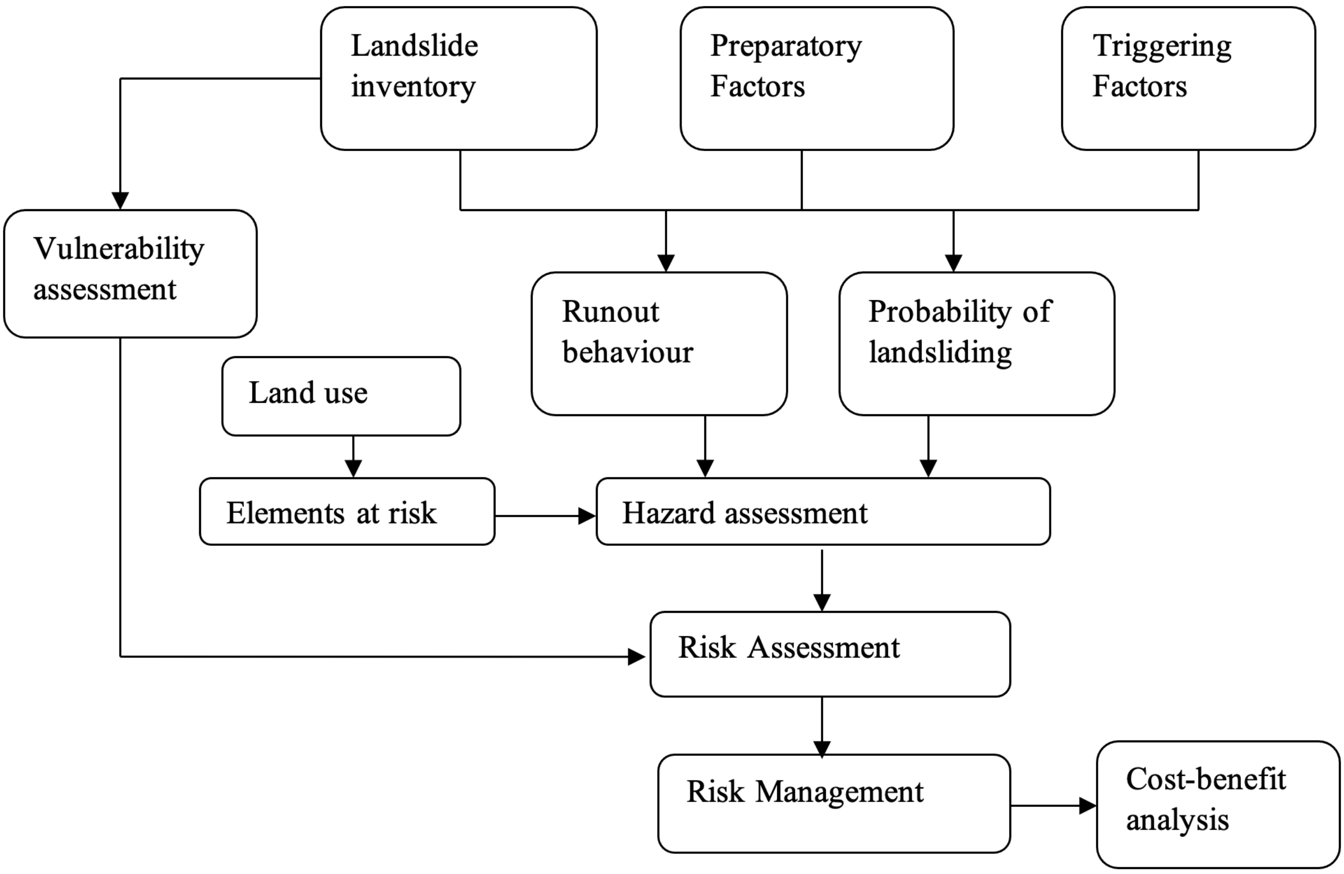

Figure 3. A framework Landslide Risk Assessment and Management

Figure 3 explains outline of a framework landslide risk assessment and management. The first step to a proper landslide hazard assessment must have thorough knowledge of past events, achieved through direct or indirect surveys [26].

Evidence of previous landslides, stress fractures, and other observable ground motion are thought to be the most helpful direct indications of landslide vulnerability. Indications of prior landslides and mass movement are therefore included in the most basic form of landslide risk assessment, suggesting that a region with previous landslides has a higher landslide risk and a higher possibility of new landslides [47]. Landslides are the consequence of a complex interplay between geological, geological, and hydrological factors that harm and disturb individuals, groups, companies, and the environment. Landslides are accelerated by human activity that modifies the environment, such as road construction and forest removal. These conditions are impacted by human activity in forests on various spatiotemporal scales. Such actions have an impact on age and plant density as well as composition, root strength, and biomass surcharge at the individual level. The climate, evaporation and transpiration and groundwater within the watershed may be impacted by these acts. Removal of aquaculture habitat, clogging of organic matter and debris during peak flows, these can degrade canals and riparian vegetation. Landslides have a regional and worldwide influence on water quality [27]. There is always a risk to the land when a landslide happens. It could be woodland, farmland, or deserted area. Transportation corridors, industrial and commercial complexes, schools, and parks are among the places that are susceptible to landslides [41]. Post-event/disaster evaluations are a crucial Component of risk and risk management. Human and physical systems about how they respond to stress they deepen our understanding. Which eventually yields more potent and effective risk-reduction strategies [43].

GIS

Using a Geographic Information System (GIS) Various types of data can be created, maintained, analysed and mapped. Location data (locations of objects), by combining different types of descriptive data with GIS links data to maps (what things are there). Many instability factors, mostly Morphological and geological character, can now be collected, stored and analysed in digital form at a reasonable cost. In example, novel morphometric parameters can be easily created over broad areas and employed as predictors of landslide occurrence by analysing elevation data and its derivatives [28].

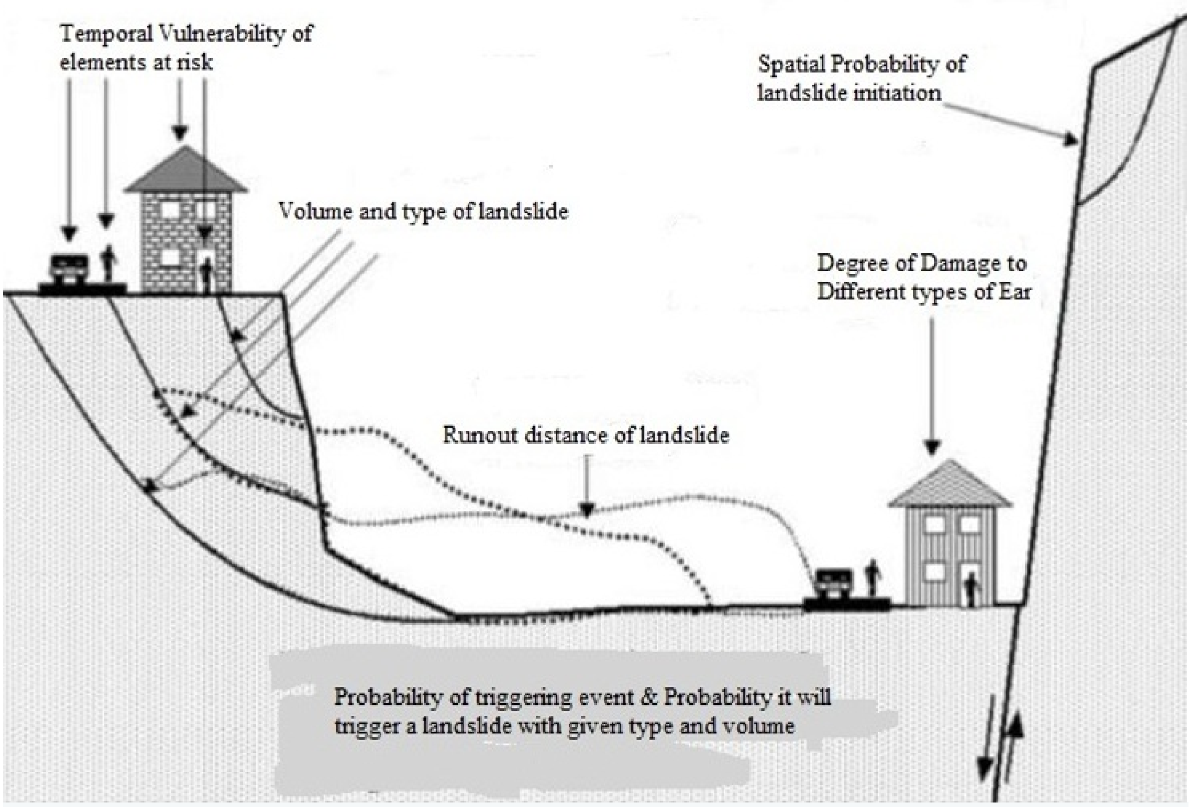

Figure 4. Illustration of some of the most problematic aspects of landslide risk assessment

Figure 4 illustrates a few of the issues with forecasting the volume of the estimated landslide, its movement range and its geographical and temporal likelihood of the risk. As a result of advancements in geographic Information Systems (GIS) technology and mathematical/statistical tools for modelling and simulation; Quantitative approaches have been developed in many areas of geoscience. More than most other fields, the research of landslide risks has welcomed these developments. The increased "user-friendliness" of GIS software encourages the delusion that natural-hazard mapping is an easy "point and click" process that can be finished quickly with minimal resources. A growing number of people use GIS to predict landslides [29]. In many regions of the world, landslide risk has been analysed and forecasted GIS is more frequently used to visualise data than to analyse it to discover new insights. However, spatial models might help in modelling natural disasters [30]. Any regional inference for a landslide hazard zone requires joint consideration of multiple factors, i.e., a "geographical (or geographic) information system" (GIS) approach is required. A GIS deals with the storage, retrieval, and analysis of various types of data at a specific geographic location [31].

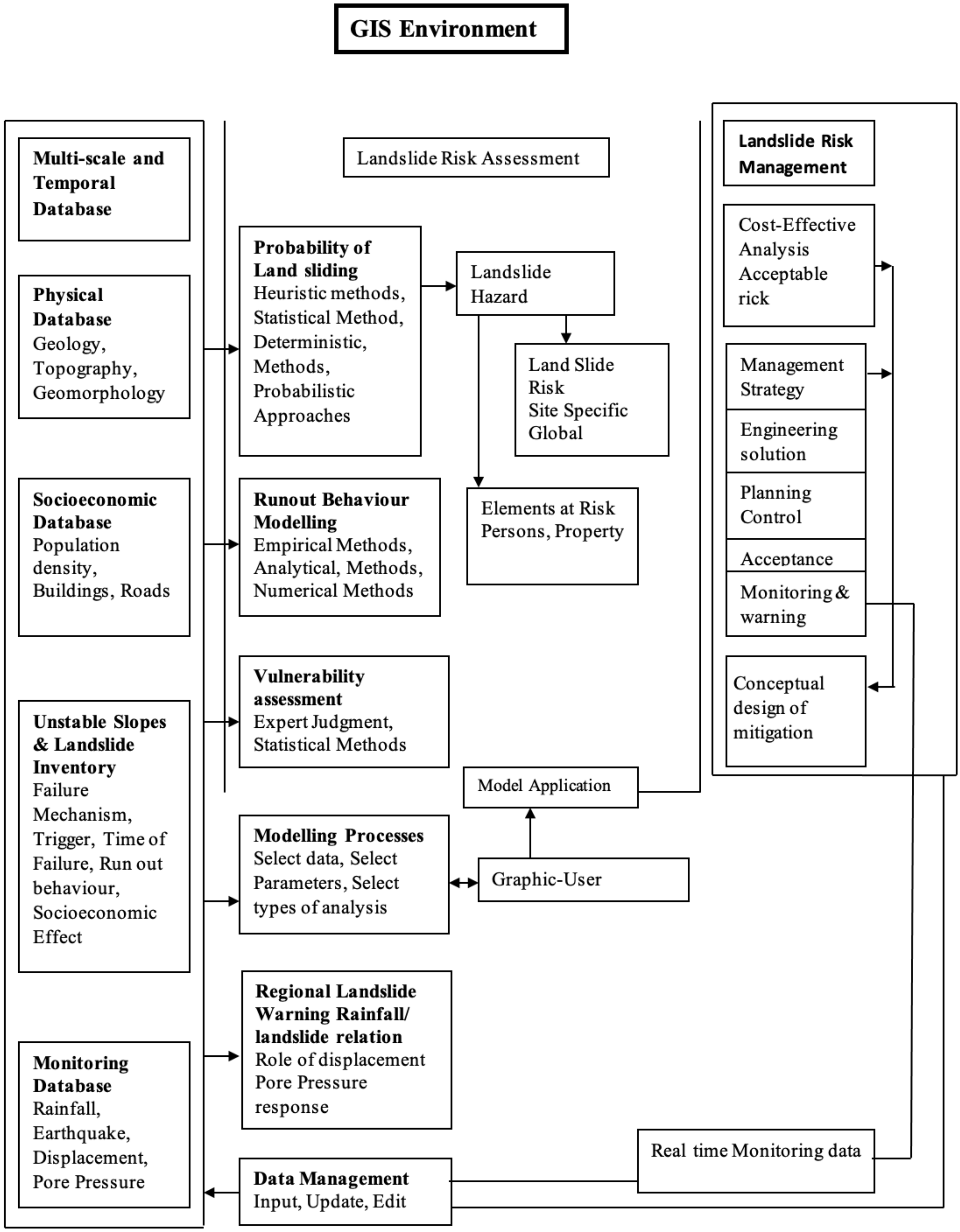

Figure 5. A GIS-based conceptual integrated system for landslide risk assessment and management.

As shown in Figure 5, these techniques can generally be integrated for the purpose of landslide risk assessment and management. For a probabilistic estimate of landslide hazard, accurate Location of landslides is essential. Such as Satellite photos and aerial photographs Use of remote sensing data, can be beneficial in acquiring important and affordable knowledge concerning landslides [49]. The locations that are vulnerable to landslides are shown on a map of landslide hazard. The elements that cause and trigger the occurrence (such as terrain, geography, and weather), as well as information on the historical distribution of landslide failures. Assessment of the danger of landslides is crucial for managing and assessing natural catastrophes. For natural and urban planning in global government policy, it is a vital stage [32].

Conclusion

Identifying the landslide hazard zone is a crucial step in the landslide management procedure. Numerous preparation and triggering elements that differ greatly from place to region have an impact on landslides. As a result, estimating the weight of a particular characteristic is challenging. Despite the fact that landslide-related losses seem to be more severe in developed nations (such as the USA, Japan, Italy, France, etc.), given the mounting environmental strain, they might cause an economic downturn or even stagnation in emerging nations. The benefit of employing hazard maps is obvious: by using them rationally, appropriately, and on time, landslides' financial costs and other effects may be considerably reduced. Risk analysis and Recent Advances in Risk Assessment Structured to improve disaster management, have begun to provide accurate procedures. As a strategy to deal with the unpredictability that accompanies landslide hazards Risk analysis and assessment have gained prominence in recent years. The management and evaluation of landslide risk should make more use of contemporary technology like GIS and remote communications. Multivariate technologies are evolving into a better tool for creating predictive and descriptive risk models as GIS's capacity for effective data manipulation grows. Obviously, the calibre of the input elements and the chosen terrain-unit type affect both their dependability and utility. Although they have some limitations, multivariate approaches are the most practical and economical ways to assess landslide risk at the regional level. This is accurate provided data collecting, processing, and analysis are done extensively and carefully using GIS methodologies.

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