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Earthquakes and Landslides Preparedness Planning in Kenya

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ABSTRACT

Kenya faces significant seismic and landslide risks due to its location along the East African Rift System. Historical earthquakes, such as the 1928 Subukia event (magnitude 6.9), have caused widespread damage, and recent deadly landslides, including the 2019 West Pokot disaster, have resulted in over 70 fatalities and the displacement of thousands. The study employs a comprehensive analytical framework encompassing vulnerability assessment, risk assessment, preparedness measures, mitigation strategies, response mechanisms, and rehabilitation protocols. A vulnerability matrix identifies residential buildings, informal settlements, rural hill communities, and vulnerable populations (children, elderly, persons with disabilities) as high-risk elements, while a risk assessment matrix reveals that landslides present more frequent and immediate threats compared to earthquakes, which though less frequent, carry potential for devastating impacts. The findings indicate that effective preparedness requires integrating early warning systems, public education, emergency drills, stockpiling of relief supplies, and evacuation planning. Mitigation strategies include hazard mapping, enforcement of building codes, slope stabilization, reforestation, and land-use planning regulations. The study highlights the stark implementation divide between developed nations with institutionalized preparedness and developing countries like Kenya facing challenges of limited resources, weak enforcement, fragmented coordination, and systemic vulnerabilities. The paper concludes that multi-faceted, collaborative, and continuous preparedness planning, incorporating scientific data with community-based approaches, is essential for reducing disaster impacts, saving lives, and minimizing economic losses. Recommendations include strengthening institutional capacity, enforcing building regulations, investing in early warning technologies, promoting community awareness, and mainstreaming disaster risk reduction into national and county development plans.

Keywords: earthquake preparedness, landslide preparedness, vulnerability assessment, risk assessment, disaster management, Kenya, East African Rift System, mitigation strategies

INTRODUCTION

An earthquake is the sudden shaking of the Earth caused by the release of energy stored in rocks along geological faults or by volcanic activity. Globally, approximately 500,000 earthquakes are detected each year, with around 100,000 being strong enough to be felt and over 100 causing significant damage (USGS, 2023). The world's most earthquake-prone areas lie along tectonic plate boundaries, such as the Pacific "Ring of Fire," which accounts for 81% of the planet's largest earthquakes (UNDRR, 2022). Countries like Japan, Indonesia, and Chile have faced devastating quakes, leading to massive economic losses and fatalities — for example, the 2011 Tōhoku earthquake caused over $235 billion in damages (World Bank, 2012). Earthquakes have far-reaching impacts: collapsing infrastructure, triggering tsunamis, causing landslides, and disrupting economies. Urban areas with dense populations and weak building codes are especially vulnerable (UNDRR, 2022). Globally, seismic hazards are being addressed through early warning systems, resilient infrastructure, and disaster risk reduction policies.

In Kenya, while not as seismically active as Japan or Chile, the risk is significant along the East African Rift System. Historical quakes like the 1928 Subukia (magnitude 6.9) caused widespread damage (Musila et al., 2019). Regions such as Naivasha and Nakuru sit near active fault lines, and geothermal activities may amplify local seismic risks (Simiyu, 2020). Given rising urbanization, Kenya must enforce building codes and adopt global best practices in seismic monitoring and preparedness (UN Habitat, 2021).

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Landslides are the downward movement of rock, soil, and debris along slopes due to gravity, often triggered by factors like heavy rainfall, earthquakes, volcanic activity, or human disturbance (UNDRR, 2022). Globally, landslides cause about 4,800 deaths annually, mostly in Asia, South America, and parts of Africa (Froude & Petley, 2018). Countries like Nepal, India, and Colombia face recurrent landslide disasters, with infrastructure damage, agricultural loss, and displacement of populations. The 2017 Sierra Leone landslide, for example, killed over 1,000 people and left thousands homeless, highlighting the deadly combination of intense rainfall, deforestation, and poor urban planning (IFRC, 2017). Globally, landslides are exacerbated by climate change, which is increasing the frequency and intensity of rainfall events, and by unsafe construction practices on vulnerable slopes. Mitigation strategies include slope stabilization, early warning systems, and land-use planning regulations (UNDRR, 2022).

In Kenya, landslides mainly affect the highland regions such as Elgeyo Marakwet, West Pokot, Murang'a, and parts of the Rift Valley. Kenya's most deadly recent event occurred in 2019 in West Pokot, where heavy rains triggered landslides that killed over 70 people and displaced thousands (Kenya Red Cross, 2019). The combination of steep terrain, deforestation, and unregulated farming on slopes increases Kenya's landslide risks (Ministry of Environment, 2021). Additionally, infrastructure projects like roads and settlements in hilly areas often lack proper slope stabilization, amplifying vulnerability. Kenya's national disaster policy encourages community awareness and afforestation as part of its mitigation strategy (NDOC, 2022).

Preparedness for earthquakes and landslides refers to the systematic planning and actions taken before disasters occur, aimed at minimizing loss of life, injury, and property damage. It encompasses early warning systems, public education, emergency drills, stockpiling of relief supplies, and development of evacuation plans. At its core, preparedness builds the capacity of communities, institutions, and governments to respond effectively when disasters strike. In developed nations, preparedness is deeply institutionalized. Countries like Japan and the United States have advanced earthquake early warning systems, strict building codes that require seismic-resistant structures, and regular community drills. Landslide-prone regions in Europe, such as Italy and Norway, employ sophisticated monitoring technologies like ground-based radar and satellite imagery to detect slope movements and issue timely warnings.

In contrast, developing countries face challenges that undermine effective preparedness. Limited financial resources often mean weak enforcement of building codes and lack of resilient infrastructure. For example, many buildings in Nepal and Haiti collapsed during major earthquakes due to poor construction practices. In landslide-prone areas of countries like the Philippines and Kenya, early warning systems are rudimentary, and many communities continue to settle in high-risk zones due to poverty and land pressure. Public awareness campaigns and evacuation drills are sporadic or absent. Additionally, institutional coordination in developing nations tends to be fragmented, slowing down response times during crises. Thus, while the concept of preparedness is globally recognized, its implementation shows a stark divide between well-resourced nations and those struggling with systemic vulnerabilities.

DISCUSSION

Vulnerability assessment

Vulnerability assessment is the process of identifying, analyzing, and evaluating the susceptibility of people, infrastructure, economies, and environments to harm from hazards (Fotopoulou & Pitilakis, 2017). It examines the conditions that increase the likelihood of damage or loss when a disaster occurs, such as poor building standards, poverty, lack of awareness, or environmental degradation. This assessment is a critical foundation in disaster preparedness planning because it helps decision-makers understand where and how to focus resources to reduce risk. In the context of earthquakes and landslides, vulnerability assessment pinpoints areas and populations most at risk (Duzgun et al., 2011). For earthquakes, it evaluates the structural integrity of buildings, population density, and emergency service readiness. For landslides, it considers slope stability, land use practices, and vegetation cover. Integrating these assessments into preparedness planning ensures that high-risk zones receive targeted mitigation measures—such as reinforcing buildings in earthquake-prone regions and stabilizing slopes or restricting construction in landslide-susceptible areas—thereby reducing potential disaster impacts (Sridharan & Gopalan, 2022).

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Vulnerability Matrix for Earthquakes and Landslides

Element at Risk	Vulnerability Factors	Level of Vulnerability	Remarks
Residential buildings	Poor construction materials, non-compliance with seismic codes, informal settlements	High	Collapse likely in earthquake zones; landslides threaten hillside homes
Public infrastructure	Inadequate design standards, aging structures	Moderate to High	Schools, hospitals, and bridges at risk of structural failure
Roads and transport systems	Located on unstable slopes, poor drainage	High	Landslides can block access routes, hindering rescue and relief operations
Urban slum communities	High population density, poor drainage, lack of land-use planning	High	High exposure and limited coping capacity
Rural hill communities	Deforestation, farming on steep slopes, lack of awareness	High	Frequent landslide incidents during heavy rains
Children and the elderly	Physical immobility, dependency	High	Struggle to evacuate during emergencies
Persons with disabilities	Limited access to warning systems, physical barriers in built environment	High	Often excluded from emergency planning
Livelihood assets (farms, markets)	Located in hazard-prone zones, limited access to recovery resources	Moderate	Disruption of economic activities and food supply chains
Emergency services	Understaffed, poorly equipped, remote coverage	Moderate	Delayed response increases disaster impacts
Communication infrastructure	Vulnerable to ground movement, power outages	Moderate	Failure can disrupt early warnings and coordination

Source: Adapted and modified from Alizadeh et al (2021).

The vulnerability assessment for earthquakes and landslides identifies critical elements within communities that are most at risk and explains why they are particularly susceptible to harm (Shao & Xu, 2022). This assessment is essential for prioritizing preparedness, mitigation, and response measures. The analysis considers both physical and social vulnerabilities, highlighting how different systems, structures, and population groups are likely to be affected during such disasters. Residential buildings are among the most vulnerable structures, especially in informal settlements where construction often does not follow seismic safety standards. Many homes are built with poor-quality materials and lack structural reinforcement, making them highly susceptible to collapse in the event of an earthquake or destruction from a landslide, particularly on steep or deforested slopes.

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Public infrastructure such as schools, hospitals, and bridges also faces moderate to high vulnerability. These structures, if not built or retrofitted to withstand seismic forces or slope instability, can fail during disasters, leading to significant casualties and disruption of essential services. Their failure can also delay rescue and relief operations, compounding the effects of the disaster. Transportation systems, including roads and bridges, are especially vulnerable in landslide-prone areas. Roads built along hillsides or lacking proper drainage can easily become blocked or destroyed during heavy rains, cutting off access to affected communities and hindering emergency response and supply chains (Jena, Pradhan & Beydoun, 2020).

Urban slum communities are at high risk due to high population density, inadequate infrastructure, poor drainage, and unregulated land use. These areas often lack proper building codes, evacuation plans, and access to emergency services, increasing both the physical and social vulnerabilities of residents. Rural hill communities also face significant risk, primarily due to deforestation, agricultural practices on steep slopes, and limited disaster awareness. During the rainy season, these areas are particularly prone to landslides, which can destroy homes, roads, and farmland, isolating communities and disrupting livelihoods (Francone, 2022).

Vulnerable population groups such as children, the elderly, and persons with disabilities face heightened risks in emergencies. Children and the elderly often have limited mobility and require assistance to evacuate or access services. Similarly, individuals with disabilities may not receive timely alerts or may face physical barriers during evacuation. These groups are often overlooked in disaster planning and therefore experience a disproportionately high level of vulnerability. Livelihood assets such as farms and markets also face moderate vulnerability. While the destruction of crops and trading centers may not directly result in casualties, it has significant implications for food security and economic stability, particularly in rural areas that rely heavily on agriculture (Fotopoulou & Pitilakis, 2017).

Emergency services themselves can be vulnerable due to understaffing, lack of equipment, or remote locations. When first responders cannot reach affected areas quickly, the impacts of the disaster are magnified. Strengthening the capacity of emergency services is therefore essential to reduce overall vulnerability. Lastly, communication infrastructure plays a vital role in disaster preparedness and response. In the event of an earthquake or landslide, power lines and communication towers may be damaged, disrupting early warning systems and coordination efforts. Although generally more robust than other systems, these networks are still moderately vulnerable and require protective measures (Francone, 2022).

Risk assessment

Risk assessment is the process of identifying, analyzing, and evaluating the potential adverse effects of hazards like earthquakes and landslides (mudslides). It determines the likelihood of an event occurring and the severity of its impacts, guiding better preparedness and mitigation planning (Dangi,Bhattarai & Thapa, 2019). Risk assessment plays a critical role in preparedness planning for earthquakes and mudslides by identifying potential hazards, vulnerable populations, and critical infrastructure at risk. It involves analyzing the likelihood and severity of these events in specific regions, allowing authorities to focus on areas that are most susceptible to damage. By evaluating factors such as fault lines, unstable slopes, soil conditions, and population density, risk assessments help determine where early warning systems, reinforced structures, and evacuation plans are most needed. This information is invaluable for allocating resources efficiently, ensuring that regions with the highest risk receive the most attention (Latifah & Sutrisnowati, 2021).

The assessment involves three main components: hazard assessment, exposure assessment, and vulnerability assessment (Kumar, Kumar & Sundriyal, 2021). Hazard Assessment analyzing the potential frequency, intensity, and spatial distribution of earthquakes and landslides in a given region. Historical data, geological conditions, seismic activity, rainfall patterns, and topographical features are key factors in understanding where and when hazards are most likely to occur. This information helps in predicting the occurrence of hazards in specific areas, enabling authorities to take proactive steps to reduce the impacts.

Exposure Assessment identifies the assets, infrastructure, and population located in hazard-prone areas that could be affected by earthquakes or landslides. These elements include residential buildings, roads, bridges, schools, hospitals, and other critical infrastructure. Additionally, it considers the economic activities in these regions,

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such as farming and industry, which may be disrupted in the event of a disaster (Song, Gao & Feng, 2018). Vulnerability Assessment to understanding how susceptible the identified elements are to damage or loss due to the hazard. It involves evaluating the structural integrity of buildings, the readiness of communities to respond, and the ability of infrastructure to withstand shocks. Vulnerability assessments consider both physical and social factors, such as building quality, population demographics, and the capacity for emergency response. By integrating these three components, risk assessment provides a comprehensive understanding of the potential threats posed by earthquakes and landslides, allowing for better preparedness and mitigation strategies (Bojadjieva, Sheshov & Bonnard, 2018). Risk Assessment Matrix combines hazard likelihood (frequency) and consequence severity (impact) to categorize risk levels. This kind of matrix helps planners prioritize preparedness and mitigation actions.

Hazard	**Probability of Occurrence**	**Severity of Impact**	**Risk Level**	**Remarks**
Earthquake (urban areas)	Low	High	Moderate	Rare but destructive; poor building standards increase damage risk
Earthquake (rural areas)	Low	Moderate	Low	Sparse population and small structures reduce casualty rates
Landslide (hilly rural areas)	High	High	High	Frequent in rainy seasons; affects homes, roads, and livelihoods
Landslide (urban informal settlements)	Moderate	High	High	Poor drainage and hillside construction increase vulnerability
Road network disruption (due to landslides)	High	Moderate	High	Transport delays hinder emergency response and supply delivery
Building collapse (due to earthquakes)	Low	High	Moderate	Especially dangerous in non-engineered buildings
Injury or death (landslide-related)	High	High	High	High risk for hillside communities and schoolchildren
Displacement of people	Moderate	Moderate to High	Moderate to High	Displacement from both hazards disrupts livelihoods and social stability
Damage to critical infrastructure	Low to Moderate	High	Moderate	Hospitals, schools, and bridges are at risk without retrofitting
Secondary hazards (e.g., flooding post-landslide)	Moderate	Moderate	Moderate	Landslide debris can block rivers, causing localized flooding

Source: Adapted and Modified from Roccati et al (2021)

This matrix shows that landslides present a more frequent and immediate risk compared to earthquakes, which, while less frequent, have the potential to cause devastating impacts. Urban informal settlements and hilly rural areas face the highest levels of risk due to a combination of poor infrastructure, deforestation, and high population density (Bojadjieva, Sheshov & Bonnard, 2018).

By identifying these risks early, decision-makers can prioritize hazard mitigation, enforce building regulations, improve land use practices, and allocate emergency resources to areas most likely to be affected.

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Preparedness

Preparedness is a vital component of disaster risk management, focusing on the planning, training, and coordination necessary to reduce the impact of earthquakes and landslides before they occur. Unlike response, which addresses immediate aftermath, preparedness involves anticipatory actions that build the capacity of individuals, communities, and institutions to act swiftly and effectively in the face of a disaster (Modica, Paleari & Rampa, 2021).

At the community level, preparedness begins with public awareness and education. Populations living in high-risk areas—such as those on steep slopes, near fault lines, or in informal settlements—must be sensitized on the signs of impending disasters, evacuation procedures, and basic first aid. Public drills, community disaster simulations, and the distribution of simplified educational materials in local languages help reinforce this knowledge and ensure it becomes second nature (Mateos, López-Vinielles & Herrera, 2020).

Early warning systems play a crucial role in preparedness. For landslides, this may include rainfall threshold monitoring, soil moisture sensors, and surveillance of ground movement using remote sensing technologies. For earthquakes, preparedness relies on seismic monitoring stations capable of detecting tremors and issuing alerts seconds before the shock reaches the surface. These systems must be linked to fast communication channels, including radio, SMS alerts, community sirens, and social media platforms, to maximize public reach (Battarra, Balcik & Xu, 2018).

Preparedness also demands institutional readiness. Government agencies, particularly disaster management authorities, must develop and regularly update contingency plans, conduct hazard mapping, and identify safe evacuation routes and assembly points. Hospitals, schools, and emergency services must be trained and equipped to handle mass casualties and infrastructural damage. Emergency drills among first responders should be routine, ensuring that search and rescue teams can be deployed swiftly and effectively (Dariagan, Atando & Asis, 2021).

Another important aspect of preparedness is the stockpiling and strategic prepositioning of essential supplies. Relief items such as tents, blankets, water purification tablets, emergency food rations, and medical kits should be stored in accessible locations near vulnerable areas. Coordination among local and national governments, non-governmental organizations (NGOs), and the private sector is necessary to ensure that these supplies can be distributed quickly when needed (Alam, 2020).

Capacity building and training are equally essential. Local disaster response committees should be formed and empowered with knowledge and tools to take immediate action. These community-level units serve as the first line of defense during an emergency and are often the most effective due to their intimate knowledge of the terrain and population. Technical training for engineers, planners, and local officials on safe construction, slope management, and emergency logistics is also critical to long-term preparedness (Shafapourtehrany et al., 2023).

Finally, financial preparedness must not be overlooked. Establishing contingency funds or insurance schemes can help governments and households recover more quickly and reduce long-term dependency on external aid. Budget allocations for disaster risk reduction should be institutionalized within national and county development plans to ensure sustainable financing (Shrestha, Shrestha & Bhandary, 2025).

Mitigation

Mitigation plays a critical role in reducing the long-term risks and impacts associated with earthquakes and landslides (Adnan, Ramli & Razak, 2015). In the context of disaster preparedness, mitigation involves proactive measures designed to eliminate or minimize the vulnerability of people, infrastructure, and the environment to these natural hazards. For Kenya, where certain regions are increasingly exposed to geophysical threats due to deforestation, poor land-use planning, and unregulated urban expansion, mitigation strategies are essential to safeguarding lives and promoting sustainable development.

One of the foundational elements of effective mitigation is hazard mapping. Accurate seismic and landslide hazard maps provide critical data on high-risk areas, helping planners and decision-makers identify vulnerable

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zones and implement targeted interventions. These maps are essential in guiding land-use policies and ensuring that development is restricted in areas prone to ground shaking or slope instability. Coupled with this, robust zoning and urban planning regulations must be enforced to prevent informal settlements on steep slopes or near fault lines, which are inherently at higher risk of catastrophic damage (Bansal, Gupta & Prasath, 2022).

Strengthening infrastructure is another cornerstone of mitigation. Earthquake-resistant building codes must be developed and enforced across the country, particularly in urban and peri-urban areas. Existing structures should be assessed and retrofitted to meet seismic safety standards. Roads, bridges, hospitals, and schools must be constructed or upgraded using resilient designs to withstand seismic tremors and landslide impacts. In rural areas, engineering measures such as terracing, retaining walls, and slope drainage systems can significantly reduce the likelihood of landslides, especially during heavy rains (Mavroulis, Diakakis & Voulgaris, 2022).

Equally important is the stabilization of soils and control of erosion. Reforestation and afforestation efforts play a vital role in anchoring soil on hillsides, reducing runoff, and maintaining slope integrity. These environmental restoration initiatives not only mitigate landslide risks but also enhance biodiversity and water conservation (Nadim & Lacasse, 2008).

Early warning systems are a modern and increasingly indispensable mitigation tool. The deployment of seismic sensors and landslide monitoring technologies allows for real-time data collection and alerts. When combined with community-based communication networks and mobile alert platforms, early warnings can enable timely evacuations and emergency responses, thereby reducing casualties and losses (Chai & Wu, 2023).

Community education and awareness are central to sustainable mitigation. Public outreach programs must be developed to inform communities about the risks associated with earthquakes and landslides, including safe construction practices, evacuation procedures, and first aid. Building a culture of preparedness empowers individuals and communities to act swiftly and appropriately in the event of a disaster (Towhata, Wang, & Massey, 2022).

From a policy and governance standpoint, mitigation requires coordinated efforts across all levels of government. Institutional capacity must be strengthened to implement, monitor, and enforce mitigation policies effectively. Disaster risk reduction should be mainstreamed into national and county development plans, ensuring that mitigation is treated not as a reactive measure but as a strategic, long-term investment (Chai & Wu, 2023).

Finally, financial mechanisms such as disaster risk insurance, emergency funds, and international cooperation must support mitigation efforts. Kenya can benefit from regional and global partnerships that offer technical expertise, funding, and innovation for risk reduction. In essence, the successful mitigation of earthquake and landslide hazards demands a multi-sectoral approach that integrates scientific knowledge, engineering practices, community engagement, and political will (Nadim & Lacasse, 2008).

Response

The response phase in earthquakes and landslides preparedness planning focuses on the immediate actions taken to save lives, reduce suffering, and protect property in the aftermath of a disaster (Xu, Liu-Zeng, Zhang & Du, 2021). This phase begins as soon as an event occurs and involves a coordinated, rapid mobilization of resources, personnel, and information to mitigate the effects of the disaster and support affected communities. One of the first and most critical components of disaster response is the activation of search and rescue operations. Specialized teams, often drawn from national disaster response units, the military, and volunteer emergency services, are deployed to locate and assist individuals trapped under debris or cut off by landslides. These teams require adequate training, modern equipment, and real-time data to operate effectively, especially in rugged terrain or collapsed structures (Rosser & Carey, 2017).

Simultaneously, emergency medical services must be mobilized to provide immediate care to the injured. Temporary medical camps, mobile clinics, or field hospitals are often set up near affected areas to treat trauma cases, manage infections, and stabilize patients before referral to larger facilities (Ren, Cheng & Liu, 2023). Medical supplies, including first aid kits, antibiotics, and emergency surgical equipment, must be readily

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available and efficiently distributed. Another critical aspect of response is the provision of shelter, food, and water to displaced individuals. Temporary shelters—such as tents, schools, or community centers—are established to house those whose homes have been destroyed or rendered unsafe. Relief agencies, both governmental and non-governmental, must coordinate to distribute essential supplies including clean drinking water, non-perishable food, blankets, and hygiene kits. Special attention should be given to vulnerable populations such as children, the elderly, and persons with disabilities (Liang, Dai, Pirasteh, & Fan, 2024).

Effective disaster response also hinges on robust communication and coordination systems. Emergency operation centers should be activated at both national and local levels to manage logistics, track resource allocation, and ensure real-time information flow. These centers play a vital role in coordinating the actions of various stakeholders including government agencies, humanitarian organizations, security forces, and local communities (González-Vida et al., 2019). Clear lines of communication also help dispel misinformation and reduce panic among the public. Security and law enforcement play a crucial role during disaster response to maintain order, protect relief assets, and prevent looting or violence. In some instances, particularly in heavily affected or isolated areas, the military may be deployed to assist in logistics, airlifting supplies, or reopening blocked roads (Ho, Shaw, Lin & Chiu, 2008).

In modern disaster management, psychosocial support is increasingly recognized as a vital part of the response. Survivors of earthquakes and landslides often experience trauma, grief, and anxiety. The presence of trained counselors or psychological first aid responders can help individuals begin to process their experiences and reduce long-term mental health consequences. Finally, continuous damage assessment must be conducted to determine the extent of destruction and the immediate needs of affected populations. This information informs both the continuation of the response phase and the transition to recovery and reconstruction. Overall, an effective response system relies on pre-established emergency plans, trained personnel, community participation, and strong institutional coordination to reduce the impact of earthquakes and landslides and pave the way for recovery (Yu, Cheng & Gao, 2012).

Rehabilitation and Reconstruction

Rehabilitation and reconstruction represent the final phase of disaster management, focusing on restoring normalcy and building back better after the immediate response to an earthquake or landslide (Gosling, Laplante-Lévesque & Sabariego, 2024). This phase aims not only to repair physical damage but also to rehabilitate the affected communities socially, economically, and psychologically, while strengthening their resilience to future disasters.

Rehabilitation involves short- to medium-term interventions that support the recovery of essential services and livelihoods. In the aftermath of an earthquake or landslide, it is critical to restore access to clean water, sanitation, healthcare, and education. Damaged water systems must be repaired or replaced to prevent disease outbreaks, and temporary schools and health centers established to maintain continuity of services. Support to affected families may include cash transfers, food aid, psycho-social support, and programs to restart disrupted livelihoods, such as farming or small businesses. Special attention should be given to vulnerable populations—including women, children, the elderly, and people with disabilities—to ensure equitable recovery (Yang, Wang, Liu & Shi, 2015).

Reconstruction, on the other hand, is a long-term effort aimed at rebuilding infrastructure and community systems with improved resilience. Houses, schools, hospitals, and roads must be reconstructed to higher safety standards, incorporating earthquake-resistant and landslide-mitigating designs. This is an opportunity to correct past planning mistakes, enforce updated building codes, and relocate communities previously settled in high-risk areas. The principle of "build back better" should guide this process, ensuring that reconstructed structures are safer, more sustainable, and adapted to future hazards (Wang, Fan, Zhang, Zheng & Xu, 2024).

Successful rehabilitation and reconstruction require coordinated planning among government agencies, local authorities, humanitarian organizations, and the affected population. Community participation is particularly important to ensure that reconstruction efforts align with local needs and cultural contexts. Additionally, this

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phase often involves significant financial investment; therefore, mobilizing resources through national budgets, donor funding, and public-private partnerships is essential (Clemente & Salvati,2017).

Another key component of this phase is institutional learning. Post-disaster reviews and evaluations should be conducted to identify what worked and what did not during the emergency and recovery phases. The findings should inform future policies and preparedness plans to enhance resilience. Investing in disaster risk reduction education, capacity building, and public awareness during this period also helps prepare communities for future events (Tang, Liu & Tang, 2020).

Environmental rehabilitation should also be prioritized, especially in areas affected by landslides. Reforestation, slope stabilization, and sustainable land-use practices help prevent further degradation and reduce the likelihood of repeat disasters. In areas impacted by earthquakes, careful urban planning must address not only infrastructure but also the spatial distribution of services and population density (Tang et al., 2020). Therefore, the rehabilitation and reconstruction phase is not just about restoring what was lost—it is about improving what existed before. When done thoughtfully and inclusively, this phase Strengthens both the physical infrastructure and the social fabric of communities, transforming vulnerability into resilience and ensuring that future disasters have a reduced impact on both people and development.

CONCLUSION AND RECOMMENDATION

Preparedness planning for earthquakes and landslides is a critical component of disaster risk management, especially in regions prone to such natural hazards. This report highlights the importance of proactive strategies that encompass risk assessment, early warning systems, community awareness, emergency response protocols, and coordination among stakeholders. Through a comprehensive understanding of geological hazards, communities and authorities can take informed measures to reduce vulnerabilities and enhance resilience. The effectiveness of preparedness efforts lies in integrating scientific data with community-based approaches. Mapping of hazard-prone areas, training first responders, and conducting regular simulation drills significantly improve readiness and response capacity. Moreover, the inclusion of local communities in planning and decision-making fosters ownership and increases the likelihood of successful implementation. Equally important are land use planning and building regulations that limit development in high-risk areas, thereby reducing exposure to landslides and earthquake damage.

Investment in infrastructure, such as seismic-resistant buildings, stabilized slopes, and proper drainage systems, further complements preparedness efforts. Additionally, education and public awareness campaigns are vital in ensuring that individuals understand the risks and know how to respond effectively during emergencies. In conclusion, preparedness for earthquakes and landslides must be multi-faceted, collaborative, and continuous. It requires the commitment of government agencies, non-governmental organizations, scientists, and local communities. With well-coordinated planning and resource allocation, the adverse impacts of these hazards can be significantly mitigated, saving lives and reducing economic losses. Strengthening preparedness today ensures a safer, more resilient tomorrow.

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