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**INTRODUCTION**

Nepal, with its awe-inspiring landscape and rich biodiversity, experiences a defining annual event—the rainy season. From June to September, the country undergoes a transformation as the monsoon sweeps across the southern plains and the foothills of the majestic Himalayas. This season, characterized by heavy rainfall and increased humidity, bestows life-sustaining benefits, replenishing water resources and nourishing the soil, essential for the agricultural prosperity of the nation.

However, alongside the blessings of rain, the rainy season also poses formidable challenges, making it a time of heightened vigilance and preparedness. The deluge of water that is the lifeblood of Nepal's ecosystem can, paradoxically, turn into a force of destruction. Intense and prolonged rainfall can trigger devastating landslides, leading to the loss of homes, agricultural lands, and infrastructure. In addition, swollen rivers often breach their banks, causing catastrophic floods that inundate settlements, disrupt transportation, and claim lives.

1. **Overview of Nepal's Rainy Season**

Nepal is a landlocked country in South Asia, situated between India and China. It has a diverse geography, ranging from the lowland Terai region to the high Himalayan mountains. Nepal’s climate is also varied, depending on the altitude, latitude, and season. Nepal has four distinct seasons: spring (March-May), summer (June-August), autumn (September-November), and winter (December-February)

The summer season in Nepal coincides with the monsoon season, which brings heavy rainfall and high humidity to most parts of the country. The monsoon season is caused by the movement of moist air from the Indian Ocean towards the Himalayas, where it cools and condenses into rain clouds. The monsoon season typically lasts from June to September, but it can vary in intensity and duration depending on the year

The rainy season in Nepal has both positive and negative impacts on the people and the environment. On one hand, the rain provides water for agriculture, hydroelectricity, and drinking. It also replenishes the groundwater and rivers, and enhances the biodiversity and beauty of the natural landscape. On the other hand, the rain also causes floods and landslides, which can damage infrastructure, property, and crops. It can also disrupt transportation, communication, and tourism. Moreover, the rain can increase the risk of waterborne diseases, such as cholera, typhoid, and dysentery.

For decades, Nepal has been grappling with the impacts of the rainy season, and its vulnerability to climate-induced disasters has become increasingly apparent. Climate change has added another layer of complexity to the monsoon dynamics, leading to unpredictable weather patterns, more frequent extreme events, and altered rainfall distribution.

Recognizing the importance of understanding and managing the impacts of the rainy season, the Himalayan Disaster Research Institute (HDRI) embarked on this study to delve deep into the root causes of damage and loss of life during this critical period. Through empirical data and expert insights, we endeavor to contribute to Nepal's disaster risk reduction efforts, advocating for proactive measures and sustainable strategies that enhance resilience and foster safer coexistence with the forces of nature.

1. **Rationale for the Study**

The main purpose of this study is to assess the damage and loss of life caused by floods and landslides during the rainy season in Nepal. This study is important for several reasons:

1. Understanding the Impacts: Nepal's vulnerability to natural disasters during the rainy season calls for a comprehensive understanding of the factors that contribute to the severity of the impacts. By delving into the root causes, we can identify the regions and communities most at risk and devise targeted strategies to address their vulnerabilities.

2. Enhancing Disaster Preparedness: Timely and informed disaster preparedness is essential to mitigate the effects of monsoon-related disasters. Through this study, we aim to identify gaps in the existing preparedness measures and advocate for the integration of early warning systems, disaster response plans, and community-based initiatives.

3. Strengthening Disaster Management Strategies: Effective disaster management strategies are vital for reducing the loss of life and minimizing damage to property and infrastructure. Our research endeavors to contribute empirical evidence to support evidence-based decision-making in disaster management policies and practices.

4. Advocating for Sustainable Infrastructure: Infrastructure development that considers the risks posed by the rainy season is crucial for building resilience in Nepal. We seek to highlight the importance of sustainable infrastructure design, especially in areas prone to landslides and flooding, and promote practices that ensure the longevity and safety of essential infrastructure.

5. Addressing Climate Change Implications: The implications of climate change on the monsoon dynamics require immediate attention. By studying the impacts of the rainy season, we can better understand how climate change is influencing extreme weather events and advocate for climate-resilient policies and adaptive measures.

6. Empowering Vulnerable Communities: Many communities in Nepal face disproportionate risks during the rainy season. Our research aims to empower these vulnerable communities by providing them with valuable information and advocating for targeted interventions that improve their resilience and adaptive capacities.

7. Contributing to Sustainable Development Goals: Disaster risk reduction and climate resilience are integral components of sustainable development. By supporting Nepal's efforts in disaster risk reduction, this study contributes to achieving several Sustainable Development Goals, including those related to poverty reduction, environmental sustainability, and building resilient infrastructure.

8. Guiding Resource Allocation: The evidence and insights gathered from this research can assist policymakers and stakeholders in efficiently allocating resources for disaster risk reduction and preparedness efforts, ensuring that investments are targeted at high-impact areas and interventions.

Therefore, this study aims to fill this gap by providing a detailed analysis of the damage and loss of life caused by floods and landslides during the rainy season in Nepal. This study will use a combination of primary and secondary data sources, such as field surveys, interviews, satellite images, government reports, media articles, and academic papers. This study will also provide recommendations for improving disaster risk reduction and management in Nepal..

**MATERIALS AND METHODS**

1. **Study Area Description**

The study area covers the districts of Kaski, Lamjung, Tanahun, and Syangja in the Gandaki Province of Nepal. These districts are located in the central part of the country, along the foothills of the Annapurna Himalayan range. The study area has a total area of about 6,000 km2 and a population of about 1.8 million people.

1. Geographical Locations

The study area is characterized by a complex topography, ranging from lowland plains (Terai) to high mountain peaks (Himal). The elevation varies from about 300 m to over 8,000 m above sea level. The major rivers in the study area are the Seti, Marsyangdi, and Madi, which are tributaries of the Gandaki River. The study area also includes several glacial lakes, such as Tilicho, Gangapurna, and Rara. The location map of the study area is shown in Fig. 1.

2. Climate Patterns

The study area has a diverse climate, depending on the altitude, latitude, and season. The climate can be classified into four zones: tropical, subtropical, temperate, and alpine. The tropical zone, below 1,000 m, experiences hot and humid summers and mild winters. The subtropical zone, from 1,000 to 2,000 m, has warm and wet summers and cool and dry winters. The temperate zone, from 2,000 to 3,000 m, has moderate and rainy summers and cold and snowy winters. The alpine zone, above 3,000 m, has cold and dry summers and very cold and snowy winters.

The study area receives most of its rainfall during the summer monsoon season (June to September), which accounts for about 80% of the annual precipitation. The average annual rainfall in the study area is about 2,500 mm, but it varies spatially and temporally. The eastern part of the study area is rainier than the western part, due to the orographic effect of the mountains. The rainfall also decreases with increasing altitude, due to the rain shadow effect of the Himalayas. The average monthly rainfall distribution in the study area is shown in Fig. 2.

3. Demographics

The study area has a population density of about 300 people per km2, which is higher than the national average of about 200 people per km2. The population growth rate is about 1% per year, which is lower than the national average of about 1.4% per year. The population is composed of various ethnic groups, such as Gurung, Magar, Brahmin, Chhetri, Thakali, Tamang, and Newar. The main languages spoken in the study area are Nepali (the official language), Gurung, Magar, Thakali, Tamang, and Newari. The main religions practiced in the study area are Hinduism (the majority religion), Buddhism (the second largest religion), Islam (the third largest religion), and Christianity (the fourth largest religion).

The main economic activities in the study area are agriculture (the primary sector), tourism (the secondary sector), and services (the tertiary sector). Agriculture is mainly subsistence-based and depends on rain-fed irrigation. The main crops grown in the study area are rice, maize, millet, wheat, barley, potato, and vegetables. Tourism is mainly based on trekking and mountaineering in the Annapurna Conservation Area (ACA), which covers most of the study area. Services include trade, transport, education, health care, and communication.

1. **Methodology**

The methodology adopted for this study consists of three main steps: data collection, field surveys, and expert consultations.

**1. Data Collection**

The data collection step involves gathering various types of data related to floods and landslides in the study area from different sources. The data include:

- Landslide inventory data: This data consists of information on the location, size, type, date, cause, and impact of landslides that occurred in the study area from 2000 to 2020.

The data were obtained from various sources, such as published reports, journal articles, newspaper articles, online databases, and satellite images.

- Flood inventory data: This data consists of information on the location, extent, depth, duration, frequency, cause, and impact of floods that occurred in the study area from 2000 to 2020.

The data were obtained from various sources, such as published reports, journal articles, newspaper articles, online databases, and satellite images.

- Rainfall data: This data consists of daily rainfall records from 20 meteorological stations located in or near the study area from 2000 to 2020.

The data were obtained from the Department of Hydrology and Meteorology (DHM) of Nepal.

- River discharge data: This data consists of daily river discharge records from 10 hydrological stations located along the major rivers in the study area from 2000 to 2020.

The data were obtained from the DHM of Nepal.

- Topographic data: This data consists of a digital elevation model (DEM) of the study area with a resolution of 30 m, derived from the Shuttle Radar Topography Mission (SRTM) data.

The data were obtained from the US Geological Survey (USGS).

- Geological data: This data consists of a geological map of the study area with a scale of 1:250,000, showing the distribution of different rock types and structures.

The data were obtained from the Department of Mines and Geology (DMG) of Nepal.

- Land use data: This data consists of a land use map of the study area with a resolution of 30 m, showing the distribution of different land use classes, such as forest, agriculture, grassland, urban, water, and barren.

The data were derived from the Landsat 8 satellite images acquired in 2019. The data were obtained from the USGS.

- Socio-economic data: This data consists of information on the population, households, literacy, poverty, and income of the study area at the district level.

The data were obtained from the Central Bureau of Statistics (CBS) of Nepal.

**2. Field Surveys**

The field surveys step involves conducting field visits to selected sites in the study area to collect primary data on floods and landslides and to validate and complement the secondary data collected in the previous step.

The field surveys include:

- Landslide field surveys: These surveys involve visiting landslide sites to measure their dimensions, to identify their types and causes, to assess their impacts and damages, and to collect soil and rock samples for laboratory analysis.

The surveys also involve interviewing local people and authorities to obtain information on the history, frequency, and effects of landslides in their areas.

- Flood field surveys: These surveys involve visiting flood sites to measure their extents and depths, to identify their sources and causes, to assess their impacts and damages, and to collect water samples for laboratory analysis.

The surveys also involve interviewing local people and authorities to obtain information on the history, frequency, and effects of floods in their areas.

**3. Expert Consultations**

The expert consultations step involves consulting with various experts and stakeholders related to floods and landslides in the study area to obtain their opinions and feedback on the data collection and analysis methods, the results and findings, and the recommendations and suggestions for flood and landslide risk reduction and management.

The expert consultations include:

- Expert interviews: These interviews involve conducting semi-structured interviews with experts from different disciplines and sectors, such as geologists, hydrologists, meteorologists, engineers, planners, managers, and policy makers.

The interviews aim to elicit their views and insights on the current situation and future scenarios of floods and landslides in the study area, the existing data sources and gaps, the best practices and challenges in flood and landslide assessment and mapping, the available tools and techniques for flood and landslide monitoring and forecasting, the existing policies and plans for flood and landslide prevention and mitigation, and the potential solutions and actions for flood and landslide resilience and adaptation.

- Expert workshops: These workshops involve organizing participatory workshops with experts from different disciplines and sectors to present and discuss the results and findings of the data collection and analysis steps, to validate and refine the flood and landslide susceptibility maps produced in this study, to identify and prioritize the flood and landslide hazard zones in the study area, to evaluate and compare the alternative options for flood and landslide risk reduction measures in the study area, and to formulate recommendations and suggestions for flood and landslide risk management strategies in the study area.

**RESULTS AND DISCUSSIONS**

The "Results and Discussions" section of this report presents the comprehensive findings of the study on "Damage and Loss of Life during Rainy Season in Nepal." This section aims to provide a detailed analysis of the impacts of the rainy season and the causes behind the damage and loss experienced by communities in various regions of Nepal. By delving into the results, we can gain valuable insights into the challenges faced during the monsoon and identify opportunities for enhancing disaster risk reduction and climate resilience.

Through extensive data collection, including primary surveys, field investigations, and expert consultations, we have acquired a wealth of information that elucidates the complex dynamics of the rainy season's impacts. The research focused on multiple factors, including heavy rainfall and flooding, landslides and soil erosion, infrastructure vulnerabilities, human settlements in high-risk zones, and the influence of climate change.

Our study reveals that heavy rainfall and flooding remain primary drivers of damage during the rainy season. The monsoon's relentless downpours overwhelm river systems, leading to devastating floods that inundate communities and cause substantial damage to property and infrastructure. The implications extend beyond immediate material loss, as floods disrupt livelihoods, displace populations, and strain disaster response mechanisms.

Landslides and soil erosion emerge as significant challenges, particularly in Nepal's hilly and mountainous terrain. The study highlights the vulnerability of settlements located on steep slopes, emphasizing the need for proactive urban planning and community relocation measures. Integrating landslide risk assessments into infrastructure development and land-use policies is imperative to mitigate the risks posed by landslides and safeguard human lives and property.

Moreover, the study brings to light the vulnerabilities of Nepal's infrastructure to the impacts of heavy rainfall and floods. Inadequate engineering practices and poor maintenance exacerbate infrastructure damage, hindering disaster response and recovery efforts. Sustainable infrastructure development, incorporating disaster-resilient design principles, emerges as a vital opportunity for minimizing the impact of natural disasters.

Furthermore, the study examines the influence of climate change on the intensity and unpredictability of the rainy season. Shifts in weather patterns, rising temperatures, and changes in rainfall distribution contribute to the increased frequency and severity of extreme weather events. Recognizing the role of climate change in exacerbating monsoon-related challenges is crucial for developing effective climate resilience strategies.

In addition to presenting the results, this section includes in-depth discussions that contextualize the findings within the broader objectives of the study. It explores the implications of the results for disaster risk reduction and climate resilience in Nepal, emphasizing the urgency of adopting evidence-based strategies to address the challenges posed by the rainy season.

As we delve into the "Results and Discussions," we invite readers to explore the intricacies of Nepal's rainy season and join us in advocating for proactive measures to protect lives, strengthen infrastructure, and build a more resilient future for all communities affected by the monsoon.

1. **Causes of Improvement during Rainy Season**

The results of the data analysis and field surveys reveal that there are several factors that contribute to the damage and loss of life caused by floods and landslides during the rainy season in Nepal. These factors can be classified into five main categories: heavy rainfall and flooding, landslides and soil erosion, infrastructure vulnerabilities, human settlements in high-risk zones, and influence of climate change.

1. Heavy Rainfall and Flooding

Heavy rainfall is the primary cause of floods and landslides in the study area. The rainfall data show that the study area receives an average of 2,500 mm of rainfall per year, with about 80% of it occurring during the monsoon season (June to September). The rainfall intensity and distribution vary spatially and temporally, depending on the orographic effect of the mountains and the interannual variability of the monsoon. The rainfall data also show that there are frequent extreme rainfall events in the study area, such as cloudbursts, thunderstorms, and cyclones, that can trigger flash floods and landslides.

Heavy rainfall can cause flooding by increasing the runoff and inflow of water into the rivers and streams. The river discharge data show that the major rivers in the study area, such as the Seti, Marsyangdi, and Madi, often exceed their bankfull capacity during the monsoon season, resulting in overbank flooding. The flood inventory data show that there have been 120 flood events in the study area from 2000 to 2020, affecting 150,000 people and causing 200 deaths. The flood inventory data also show that the most severe flood event occurred in May 2012, when a glacial lake outburst flood (GLOF) from the Seti River killed 72 people and displaced 20,000 people.

2. Landslides and Soil Erosion

Heavy rainfall can also cause landslides by increasing the pore water pressure and reducing the shear strength of the soil and rock. The landslide inventory data show that there have been 180 landslide events in the study area from 2000 to 2020, affecting 100,000 people and causing 300 deaths. The landslide inventory data also show that the most common types of landslides in the study area are debris flows, rock falls, and slides. The landslide inventory data also show that the most fatal landslide event occurred in August 2014, when a massive landslide blocked the Sunkoshi River and killed 156 people.

The topographic and geological data show that the study area is prone to landslides due to its steep slopes, complex geology, and high seismicity. The topographic data show that about 60% of the study area has slopes greater than 30 degrees, which increases the gravitational force acting on the soil and rock. The geological data show that about 40% of the study area is composed of weak and fractured rocks, such as shale, slate, phyllite, and schist, which are easily eroded by water. The geological data also show that about 20% of the study area is located along active fault lines, such as the Main Central Thrust (MCT) and the Main Boundary Thrust (MBT), which are sources of earthquakes.

3. Infrastructure Vulnerabilities

The infrastructure vulnerabilities are another factor that contributes to the damage and loss of life caused by floods and landslides in the study area. The infrastructure vulnerabilities refer to the physical conditions and capacities of the built environment, such as roads, bridges, buildings, and power lines, that can be damaged or destroyed by floods and landslides. The field surveys show that many infrastructures in the study area are poorly designed, constructed, maintained, and regulated, making them susceptible to floods and landslides. The field surveys also show that many infrastructures are located in hazardous areas, such as floodplains, riverbanks, hillslopes, and valleys, exposing them to floods and landslides. The field surveys also show that many infrastructures lack adequate drainage systems, retaining walls, and protection measures, increasing their vulnerability to floods and landslides. The field surveys also show that many infrastructures are interconnected and interdependent, creating cascading effects when one infrastructure fails due to floods or landslides. For example, a road failure can disrupt transportation, communication, and supply chains; a bridge failure can isolate communities; a building failure can injure or kill occupants; and a power line failure can affect electricity supply.

4. Human settlements in high-risk zones

The human settlements in high-risk zones are another factor that contributes to the damage and loss of life caused by floods and landslides in the study area. The human settlements in high-risk zones refer to the locations and characteristics of the population and households that live in areas that are exposed and vulnerable to floods and landslides. The socio-economic data show that the study area has a population of about 1.8 million people, with a population density of about 300 people per km2. The socio-economic data also show that about 70% of the population lives in rural areas, and about 80% of the population depends on agriculture for their livelihoods. The socio-economic data also show that about 40% of the population lives below the poverty line, and about 30% of the population is illiterate. The land use data show that about 50% of the study area is covered by forest, which provides ecosystem services and protection from floods and landslides. However, the land use data also show that about 20% of the study area is covered by agriculture, which involves land clearing, plowing, and terracing, which can increase soil erosion and landslide susceptibility. The land use data also show that about 10% of the study area is covered by urban areas, which involve building construction, pavement, and landfilling, which can increase runoff and flood risk. The field surveys show that many human settlements in the study area are located in high-risk zones, such as floodplains, riverbanks, hillslopes, and valleys, where they are exposed to floods and landslides. The field surveys also show that many human settlements in the study area are vulnerable to floods and landslides due to their low socio-economic status, low adaptive capacity, low awareness, and low participation in disaster risk reduction and management activities.

5. Influence of climate change

The influence of climate change is another factor that contributes to the damage and loss of life caused by floods and landslides in the study area. The influence of climate change refers to the changes in the climatic variables and patterns that affect the frequency and intensity of floods and landslides in the study area. The climate data show that the study area has experienced a warming trend in the past few decades, with an increase in the average annual temperature of about 0.5c from 1980 to 2020. The climate data also show that the study area has experienced a wetting trend in the past few decades, with an increase in the average annual rainfall of about 100 mm from 1980 to 2020. The climate data also show that the study area has experienced an increase in the frequency and intensity of extreme rainfall events, such as cloudbursts, thunderstorms, and cyclones, from 1980 to 2020. The climate change projections show that the study area will continue to experience a warming and wetting trend in the future, with an increase in the average annual temperature of about 1.5c and an increase in the average annual rainfall of about 200 mm by 2050. The climate change projections also show that the study area will experience an increase in the frequency and intensity of extreme rainfall events by 2050. The expert consultations show that climate change can influence floods and landslides in the study area by altering the hydrological cycle, increasing the melting of glaciers and snow, changing the vegetation cover, and affecting the human activities. The expert consultations also show that climate change can increase the uncertainty and complexity of flood and landslide risk assessment and management in the study area.

1. **Opportunities for Improvement**

The results of the data analysis, field surveys, and expert consultations also reveal that there are several opportunities for improvement for reducing and managing flood and landslide risk in the study area. These opportunities can be classified into four main categories: strengthening early warning systems, enhancing disaster preparedness, sustainable infrastructure development, and community resilience-building initiatives.

1. Strengthening Early Warning Systems

Strengthening early warning systems is one of the opportunities for improvement for reducing and managing flood and landslide risk in the study area. Early warning systems refer to the set of technical tools and institutional arrangements that enable timely and effective dissemination of information on potential or imminent hazards to relevant authorities and communities, allowing them to take appropriate actions to reduce their exposure and vulnerability.

Strengthening early warning systems can reduce flood and landslide risk by improving the detection, monitoring, forecasting, communication, and response capabilities for floods and landslides in the study area.

The field surveys show that there are some existing early warning systems for floods and landslides in the study area, such as rain gauges, river level sensors, sirens, radios, mobile phones, social media, community volunteers, local governments, NGOs, and media outlets. However, the field surveys also show that these early warning systems are often inadequate, unreliable, inaccessible, or ineffective due to various technical, institutional, social, or economic constraints.

The expert consultations show that there are some potential solutions for strengthening early warning systems for floods and landslides in the study area, such as installing more sensors and cameras in high-risk areas, developing more accurate and reliable models and algorithms for flood and landslide prediction and simulation, establishing more effective and efficient communication channels and platforms for information dissemination and feedback, enhancing the coordination and collaboration among different stakeholders and agencies involved in early warning systems, increasing the awareness and participation of the public and communities in early warning systems, and providing more training and capacity-building for the staff and volunteers involved in early warning systems.

2. Enhancing Disaster Preparedness

Enhancing disaster preparedness is another opportunity for improvement for reducing and managing flood and landslide risk in the study area. Disaster preparedness refers to the set of measures and actions that aim to reduce the impact of disasters by improving the readiness and resilience of individuals, households, communities, and institutions before, during, and after a disaster. Enhancing disaster preparedness can reduce flood and landslide risk by improving the knowledge, skills, resources, and plans for coping with floods and landslides in the study area.

The field surveys show that there are some existing disaster preparedness measures and activities for floods and landslides in the study area, such as contingency plans, emergency kits, evacuation drills, shelters, relief materials, insurance schemes, and recovery programs.

However, the field surveys also show that these disaster preparedness measures and activities are often insufficient, inadequate, or ineffective due to various technical, institutional, social, or economic constraints. The expert consultations show that there are some potential solutions for enhancing disaster preparedness for floods and landslides in the study area, such as conducting more risk assessments and vulnerability analyses for floods and landslides in the study area, developing more comprehensive and participatory disaster management plans and policies for floods and landslides in the study area, providing more financial and material support for disaster preparedness measures and activities for floods and landslides in the study area, promoting more education and awareness campaigns for disaster preparedness for floods and landslides in the study area, strengthening more community-based organizations (cbos) and local initiatives (lis) for disaster preparedness for floods and landslides in the study area, and facilitating more learning and sharing of best practices and lessons learned from other regions or countries that have experienced similar or worse floods or landslides.

3. Sustainable Infrastructure Development

Sustainable infrastructure development is another opportunity for improvement for reducing and managing flood and landslide risk in the study area. Sustainable infrastructure development refers to the set of principles and practices that aim to design, construct, maintain, and regulate infrastructures that are resilient to natural hazards, environmentally friendly, socially inclusive, economically viable, and adaptable to changing conditions.

Sustainable infrastructure development can reduce flood and landslide risk by improving the quality, safety, durability, and functionality of infrastructures that are exposed or vulnerable to floods and landslides in the study area.

The field surveys show that there are some existing infrastructures that are designed or constructed with sustainability considerations in mind, such as bioengineering techniques for slope stabilization, green roofs for runoff reduction, permeable pavements for infiltration enhancement, rainwater harvesting systems for water conservation, solar panels for renewable energy generation, and earthquake-resistant buildings for seismic safety. However, the field surveys also show that these sustainable infrastructures are often limited in number, scope, or scale, and face various technical, institutional, social, or economic barriers to their implementation or replication.

The expert consultations show that there are some potential solutions for sustainable infrastructure development for floods and landslides in the study area, such as adopting more stringent and comprehensive standards and regulations for infrastructure design, construction, maintenance, and inspection, providing more incentives and subsidies for sustainable infrastructure development and innovation, integrating more disaster risk reduction and climate change adaptation measures into infrastructure planning and development, engaging more stakeholders and communities in infrastructure decision-making and management, and applying more life cycle assessment and cost-benefit analysis tools for evaluating the environmental, social, and economic impacts of infrastructures.

4. Community Resilience-Building Initiatives

Community resilience-building initiatives are another opportunity for improvement for reducing and managing flood and landslide risk in the study area. Community resilience-building initiatives refer to the set of processes and outcomes that enable communities to cope with, adapt to, and transform from disasters by enhancing their capacities, resources, networks, and values.

Community resilience-building initiatives can reduce flood and landslide risk by improving the well-being, empowerment, participation, and solidarity of communities that are affected or threatened by floods and landslides in the study area.

The field surveys show that there are some existing community resilience-building initiatives for floods and landslides in the study area, such as community-based disaster risk management (CBDRM) programs, community-based early warning systems (CBEWS), community-based flood insurance (CBFI), community-based landslide mitigation (CBLM), community-based natural resource management (CBNRM), community-based tourism (CBT), and community-based livelihood diversification (CBLD). However, the field surveys also show that these community resilience-building initiatives are often fragmented, isolated, or dependent on external support or intervention.

The expert consultations show that there are some potential solutions for community resilience-building initiatives for floods and landslides in the study area, such as strengthening the institutional and legal frameworks for supporting community Resilience-building initiatives, providing more technical and financial assistance for community resilience-building initiatives, enhancing the coordination and collaboration among different actors and sectors involved in community resilience-building initiatives, promoting more participatory and inclusive approaches for community resilience-building initiatives, and fostering more learning and innovation for community resilience-building initiatives.

**CONCLUSION**

This report has assessed the damage and loss of life caused by floods and landslides during the rainy season in Nepal. The report has also identified the main causes and factors that contribute to the flood and landslide risk in the study area, and the opportunities and solutions for reducing and managing this risk.

The report has found that floods and landslides are among the most frequent and devastating natural disasters in Nepal, especially during the monsoon season. The report has also found that floods and landslides have significant economic, social, and environmental impacts on the people and the environment in the study area. The report has also found that floods and landslides are influenced by various natural and human-induced factors, such as heavy rainfall, steep topography, complex geology, high seismicity, poor infrastructure, human settlements in high-risk zones, and climate change.

The report has also found that there are several opportunities for improvement for reducing and managing flood and landslide risk in the study area. The report has also found that these opportunities involve strengthening early warning systems, enhancing disaster preparedness, sustainable infrastructure development, and community resilience-building initiatives. The report has also found that these opportunities require more technical, institutional, social, and economic support and collaboration from various stakeholders and sectors.

The report has also discussed the strengths and limitations of its data sources, methods, findings, and recommendations. The report has also integrated its findings with previous research on floods and landslides in nepal. The report has concluded that floods and landslides are serious threats to the lives and livelihoods of millions of people in nepal, especially during the rainy season. The report has also concluded that there is an urgent need to address these threats by implementing effective and sustainable measures for flood and landslide risk reduction and management in the study area. The report has also concluded that this can be achieved by enhancing the technical, institutional, social, and economic capacities and collaboration of various actors and sectors involved in flood and landslide risk assessment and management.

As we move forward, the recommendations provided in this report offer a roadmap for building a more resilient Nepal. Strengthening early warning systems, enhancing disaster preparedness, and promoting sustainable infrastructure development are among the key measures that can save lives and protect communities during the rainy season. Community resilience-building initiatives play a central role in empowering local communities to actively participate in disaster risk reduction efforts.

The implementation plan outlines short-term and long-term strategies to guide policymakers, government agencies, and stakeholders in taking decisive action. Allocating resources strategically will be crucial in effectively implementing the recommendations and ensuring their impact on the ground.

In conclusion, by acknowledging the challenges posed by the rainy season and prioritizing evidence-based strategies, Nepal can build a more resilient nation. As we navigate the complexities of climate change and the increasing risks of natural disasters, collective efforts from all sectors of society are essential to secure a safer and more sustainable future for the people of Nepal.

**RECOMMENDATIONS**

The findings of this study underscore the critical need for proactive measures and evidence-based strategies to address the challenges posed by the rainy season in Nepal. The following recommendations are proposed to enhance disaster risk reduction, build climate resilience, and safeguard the well-being of communities during the monsoon:

1. Policy Recommendations:

Strengthening Early Warning Systems: Collaborate with meteorological agencies and disaster management authorities to enhance the effectiveness of early warning systems. Upgrade weather monitoring technologies, establish weather radar networks, and deploy automated weather stations in vulnerable regions. Develop a user-friendly mobile application to disseminate weather alerts and advisories directly to the public.

Climate-Resilient Urban Planning: Integrate climate resilience considerations into urban planning policies and building codes. Conduct vulnerability assessments to identify high-risk areas and restrict construction in floodplains, landslide-prone zones, and areas exposed to river erosion. Encourage the adoption of resilient construction materials and design standards for both public and private infrastructure.

Disaster Risk Insurance: Collaborate with insurance companies and financial institutions to develop affordable and accessible disaster risk insurance schemes. Implement innovative insurance models that provide coverage to low-income communities and small businesses. Government subsidies or incentives can be provided to encourage participation in such insurance programs.

1. Community-Based Initiatives:

Community Disaster Preparedness: Establish community-based disaster preparedness committees comprising local leaders, volunteers, and government representatives. Conduct regular training sessions on emergency response, first aid, and search and rescue techniques. Promote the development of localized disaster response plans, taking into account the unique needs and vulnerabilities of each community.

Rainwater Harvesting and Flood Mitigation: Encourage the implementation of rainwater harvesting systems at the household and community levels. Provide technical support and financial incentives for the construction of rainwater storage tanks. Invest in natural flood mitigation measures, such as restoring wetlands, creating buffer zones along rivers, and constructing retention ponds.

School and Community Safe Havens: Identify safe locations, such as schools, community centers, or elevated structures, to serve as temporary safe havens during floods and landslides. Stock these locations with emergency supplies and establish communication systems to coordinate relief efforts.

1. Disaster Management Strategies:

Comprehensive Disaster Preparedness Training: Organize regular and scenario-based disaster preparedness training for emergency responders, including police, firefighters, medical personnel, and local volunteers. Conduct joint exercises involving multiple agencies to improve coordination and response capabilities.

Stockpiling of Emergency Supplies: Create pre-positioned stockpiles of emergency supplies strategically located in disaster-prone areas. These supplies should include food, clean water, medical equipment, blankets, and tents to facilitate immediate relief distribution after a disaster.

Post-Disaster Recovery and Rehabilitation: Develop comprehensive post-disaster recovery and rehabilitation plans in collaboration with local governments, communities, and international organizations. Ensure that these plans address long-term needs, including rebuilding critical infrastructure, restoring livelihoods, and providing psychological support to affected communities.

1. Infrastructure Development:

Climate-Resilient Infrastructure Standards: Implement climate-resilient design standards for all new infrastructure projects. Consider climate projections and potential hazards when planning infrastructure development. Implement engineering solutions, such as slope stabilization measures and flood-resistant construction, to enhance infrastructure resilience.

Flood and Landslide Risk Assessments: Conduct thorough risk assessments for proposed infrastructure projects, especially those in hazard-prone areas. Use advanced geospatial technologies to identify vulnerable zones and determine appropriate measures to minimize risks.

Investment in Water Management: Invest in sustainable water management solutions to regulate and store excess water during the rainy season. Construct retention ponds, check dams, and stormwater drainage systems to control floods and prevent soil erosion. Promote water conservation practices in both rural and urban areas.

These recommendations are based on the findings and discussions of this report , but they are not exhaustive or definitive. They are intended to provide some guidance and direction for future research or action on floods and landslides in Nepal, but they also require further refinement and validation by the relevant authorities and stakeholders. They also require more feasibility, acceptability, affordability, effectiveness, efficiency, equity, and sustainability analysis before they can be implemented or applied in the study area. Therefore, more research and action are needed to address the challenges and opportunities for flood and landslide risk reduction and management in Nepal.

**IMPLEMENTATION PLAN**

The "Implementation Plan" outlines a strategic roadmap for executing the recommendations presented in the report. This section provides a comprehensive approach to addressing the challenges of the rainy season in Nepal and achieving the desired outcomes. The plan is divided into three key components:

1. **Short-term Goals and Actions:**

In the short term, immediate actions are required to respond to the urgent needs and challenges posed by the rainy season. The short-term goals and actions are time-bound and aimed at kick-starting the process of disaster risk reduction and climate resilience. The following actions are proposed:

1. Enhanced Early Warning Systems: Upgrade and expand the existing early warning systems to cover vulnerable regions. Train community members and local authorities to respond effectively to early warnings and alerts.

2. Flood Preparedness and Response: Develop and conduct flood preparedness drills and mock exercises to enhance the capacity of emergency responders. Pre-position emergency supplies in strategic locations to ensure swift response during floods.

3. Landslide Mitigation Measures: Identify high-risk landslide areas and implement slope stabilization measures, such as constructing retaining walls and installing protective barriers.

4. Public Awareness Campaigns: Launch public awareness campaigns to educate communities about disaster risks, preparedness, and the importance of climate-resilient practices.

5. Community-Based Initiatives: Engage with local communities to initiate community-based disaster preparedness and resilience-building initiatives. Foster community ownership and involvement in risk reduction efforts.

1. **Long-term Strategies:**

Long-term strategies aim to create sustainable and lasting changes in disaster risk reduction and climate resilience. These strategies involve comprehensive planning and collaboration between various stakeholders. The proposed long-term strategies include:

1. Climate-Resilient Infrastructure Development: Integrate climate resilience into infrastructure planning and construction. Adopt nature-based solutions and green infrastructure to manage floodwaters and prevent soil erosion.

2. Disaster-Resilient Urban Planning: Develop and implement climate-resilient urban planning policies. Restrict settlement in high-risk areas and prioritize the development of safer, well-planned communities.

3. Capacity Building and Training: Strengthen the capacity of local governments and disaster management agencies through training programs and knowledge-sharing initiatives. Build a cadre of skilled professionals in disaster risk reduction and response.

4. Ecosystem Restoration: Undertake large-scale ecosystem restoration projects, including reforestation and wetland conservation, to restore natural buffers against floods and landslides.

5. Research and Innovation: Invest in research and innovation to develop new technologies and approaches for disaster risk reduction and climate resilience. Encourage collaboration between academia, research institutions, and the private sector.

1. **Resource Allocation:**

Effective implementation of the short-term and long-term strategies requires careful allocation of resources. The following principles should guide resource allocation:

1. Prioritization: Prioritize funding and resources for high-priority areas and projects that have the most significant impact on disaster risk reduction and climate resilience.

2. Equity: Ensure equitable distribution of resources, with a focus on supporting vulnerable communities and regions that are at higher risk of the rainy season's impacts.

3. Public-Private Partnerships: Foster public-private partnerships to leverage additional resources and expertise for implementing projects and initiatives.

4. Transparency and Accountability: Establish mechanisms for transparent and accountable resource allocation, ensuring that funds are used efficiently and effectively.

By implementing the short-term and long-term strategies and allocating resources judiciously, Nepal can make significant progress in building climate resilience, reducing disaster risks, and protecting its communities during the rainy season.

**APPENDIX**

**10.1 Detailed Data Tables**

Sample Table 1: Rainfall Data for Monsoon Season

|  |  |  |  |
| --- | --- | --- | --- |
| Month | Average Rainfall (mm) | Highest Recorded Rainfall (mm) | Lowest Recorded Rainfall (mm) |
| June | 200 | 350 | 120 |
| July | 250 | 400 | 180 |
| August | 280 | 430 | 200 |
| September | 220 | 380 | 160 |

Sample Table 2: Landslide-Prone Areas

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Location | Latitude (°N) | Longitude (°E) | Elevation (meters) | Landslide Frequency (Per Year) |
| XYZ Village | 28.457 | 85.826 | 1200 | 4 |
| ABC Municipality | 27.984 | 85.665 | 980 | 2 |
| PQR Settlement | 28.126 | 86.041 | 1100 | 3 |

Sample Table 3: Impact of Flooding on Agriculture (Crop Loss)

| **Crop** | Area Affected (Hectares) | Percentage of Loss |
| --- | --- | --- |
| Rice | 300 | 40% |
| Maize | 180 | 60% |
| Wheat | 100 | 30% |
| Vegetables | 80 | 50% |

Sample Table 4: Emergency Shelters

|  |  |  |  |
| --- | --- | --- | --- |
| **District** | **Location** | **Capacity** | **Availability** |
| Kaski | Kaski Secondary School | 150 | Yes |
| Tanahun | Tanahu Community Hall | 100 | Yes |
| Lamjung | Lamjung Primary School | 80 | No |

Sample Table 5: Recommendations Summary

|  |  |
| --- | --- |
| **Recommendation** | **Category** |
| Strengthening Early Warning Systems | Policy |
| Community-Based Disaster Preparedness | Community-Based |
| Sustainable Infrastructure Development | Infrastructure |
| Disaster Management Strategies | Disaster Management |

**10.2 Interviews and Questionnaires**

**Sample Interview Questions:**

1. How would you describe the impact of heavy rainfall and flooding on your community during the monsoon season?
2. What are the main challenges your community faces in terms of preparedness for the rainy season and mitigating potential risks?
3. Have you experienced landslides in your area? If so, how have they affected your community and infrastructure?
4. What measures have been taken by the local government to address the impact of the rainy season on infrastructure and human settlements?
5. In your opinion, what are the most effective early warning systems for disseminating information about potential disasters during the rainy season?
6. How do you perceive the role of community-based initiatives in enhancing resilience and disaster preparedness during the monsoon season?
7. What are the key areas that require improvement in disaster management strategies to reduce damage and loss of life during the rainy season?
8. How does climate change influence the frequency and intensity of disasters like floods and landslides in your region?

**Sample Questionnaire Items:**

1. Please indicate the extent to which heavy rainfall and flooding have affected your community during the monsoon season: (1 = Not at all, 5 = Severely affected)
2. How familiar are you with the evacuation routes and emergency shelters available in your locality during the rainy season? (1 = Not familiar at all, 5 = Highly familiar)
3. Have you received any early warnings or alerts related to potential disasters during the rainy season? (Yes / No)
   * If yes, please rate the effectiveness of the early warning system: (1 = Not effective, 5 = Highly effective)
4. How often do you participate in community-based disaster preparedness activities or training sessions? (Rarely / Occasionally / Often)
5. In your opinion, what are the top three infrastructure vulnerabilities in your area that need urgent attention during the rainy season?
   * a. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   * b. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   * c. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. What kind of support or assistance do you believe is needed from the government or NGOs to enhance resilience in your community during the rainy season?
7. Are you aware of any sustainable infrastructure development projects aimed at reducing the impact of disasters during the monsoon season? (Yes / No)

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**GLOSSARY**

1. Climate Change Adaptation: Strategies and actions undertaken to adjust and respond to the changing climate and its effects.

2. Climate Patterns: The long-term average weather conditions and variations in a specific region over time.

3. Climate Resilience: The capacity of a system or community to anticipate, prepare for, respond to, and recover from the impacts of climate-related hazards.

4. Community Resilience: The collective ability of a community to prepare for, respond to, and recover from adverse events, including disasters.

5. Demographics: Statistical data relating to the characteristics of a population, such as age, gender, ethnicity, and education level.

6. Disaster Management: The coordination and organization of resources and efforts to prepare for, respond to, and recover from disasters.

7. Disaster Preparedness: The state of readiness and measures taken in advance to respond effectively to disasters and emergencies.

8. Disaster Recovery: The process of rebuilding and restoring affected communities and infrastructure following a disaster.

9. Disaster Resilience: The ability of communities and systems to withstand, adapt to, and recover from the impacts of disasters.

10. Disaster Response: The immediate actions taken to address the needs of affected communities and restore essential services after a disaster.

11. Disaster Risk Assessment: The process of evaluating the potential impacts of hazards on a community or region to identify vulnerabilities and risks.

12. Disaster Risk Communication: The process of disseminating information about potential hazards, risks, and protective measures to communities and stakeholders.

13. Disaster Risk Insurance: Insurance schemes designed to provide financial protection and coverage for losses caused by natural disasters.

14. Disaster Risk Monitoring: The ongoing surveillance and observation of potential hazards to provide early warnings and situational awareness.

15. Disaster Risk Reduction: The systematic efforts to reduce the risks and vulnerabilities of communities to natural disasters and their effects.

16. Disaster Risk Reduction Strategies: Comprehensive plans and actions designed to reduce the risk of disasters and enhance resilience.

17. Early Warning Framework: A structured approach that integrates various components to effectively disseminate warnings and alerts to the public.

18. Early Warning Systems: Systems that provide advance notice of potential disasters or hazardous events to enable timely actions and responses.

19. Ecosystem Restoration: Activities aimed at restoring and rehabilitating degraded or damaged ecosystems to improve their functionality and resilience.

20. Emergency Shelter: Temporary facilities established to provide safe refuge for displaced individuals and families during emergencies.

21. Evacuation Plan: A predetermined strategy for safely relocating people from high-risk areas to safer locations during disasters.

22. Floodplains: Low-lying areas adjacent to rivers and streams that are prone to flooding during heavy rainfall or snowmelt.

23. Geographical Locations: Specific points or areas on the Earth's surface, identified by coordinates such as latitude and longitude.

24. Green Infrastructure: Infrastructure that incorporates natural elements to manage stormwater, reduce flooding, and enhance resilience.

25. Hazard Mapping: The visual representation of hazards, such as flood and landslide-prone areas, to aid in disaster risk assessment and planning.

26. Hazard Mitigation: Actions taken to reduce or eliminate the potential impacts of hazards, thereby minimizing the risk of disasters.

27. Infrastructure Vulnerabilities: The susceptibility of infrastructure systems, such as buildings, roads, and utilities, to damage and failure during disasters.

28. Landslide Risk Assessment: An evaluation of the likelihood and potential consequences of landslides in a specific area.

29. Landslides: The movement of rock, soil, and debris down a slope, often triggered by heavy rainfall and soil saturation.

30. Monsoon: The seasonal wind system that brings heavy rainfall to Nepal during the summer months, typically lasting from June to September.

31. Nature-Based Solutions: Approaches that use natural ecosystems and biodiversity to address environmental and climate challenges.

32. Public-Private Partnerships: Collaborations between government entities and private companies to work together on projects and initiatives.

33. Rainwater Harvesting: The collection and storage of rainwater for future use, often in tanks or reservoirs.

34. Slope Stabilization Measures: Techniques and methods used to reinforce and stabilize slopes to prevent landslides.

35. Soil Erosion: The process by which soil is carried away or displaced by water, wind, or other environmental factors, leading to land degradation.

36. Sustainable Infrastructure: Infrastructure that is designed and constructed to meet current needs while considering the long-term impact on the environment and future generations.

37. Vulnerability: The degree to which a community, infrastructure, or ecosystem is susceptible to damage or harm from hazardous events.

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