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Natural Hazards and Community Resilience in Palungtar: A Case Study of Fire, Flood, and Landslide Events

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Abstract

Palungtar Municipality, located in Gorkha District of central Nepal, is increasingly vulnerable to multiple natural hazards, particularly forest fires, floods, and landslides. These hazards threaten lives, infrastructure, and livelihoods, particularly in rural and riverine settlements. The objective of this study is to assess the spatial distribution and impact of these hazards and to evaluate the level of community resilience in Palungtar. The research specifically aims to identify hazard-prone areas and analyze how local communities adapt and respond to these recurring environmental threats. A mixed-method approach was adopted, combining qualitative data from field observations, key informant interviews, and focus group discussions with quantitative spatial analysis using environmental datasets. MaxEnt (Maximum Entropy) modeling was applied to identify potential hazard zones based on topographic, climatic, vegetation-related, and anthropogenic variables. GIS-based layers were processed and standardized to a 30-meter resolution for compatibility. Field verification was conducted to confirm model outputs and document local impacts and coping strategies. The findings reveal spatially distinct high-risk zones for fire, flood, and landslide events across various wards of Palungtar. Community responses include traditional practices such as terracing, bio-fencing, elevated storage, and informal fire control, but institutional preparedness remains limited. The study concludes that while local communities exhibit resilience through experience and social networks, structural mitigation, early warning systems, and capacity building are urgently needed. This case study provides an empirical foundation for integrated hazard management and resilience planning in similar rural municipalities across the Himalayan region.

Kewords: Hazards, landslide, spatial analysis, mitigation, community, disaster

Background

Nepal is one of the most disaster-prone countries in the world due to its rugged topography, active tectonic setting, monsoon-dependent climate, and increasing anthropogenic pressures. The country faces recurring hazards such as floods, landslides, and wildfires, which result in significant loss of life, livelihoods, and infrastructure each year (MoHA, 2020). In Nepal, each year, the country suffers substantial human and economic losses due to disasters such as floods, landslides, wildfires, and

earthquakes. The United Nations Development Programme/Bureau of Crisis Prevention and Recovery ranks Nepal among the most disaster-prone nations globally, identifying it as the 20th most vulnerable country to multi-hazards, 4th in terms of climate change-related risks, 11th for earthquake vulnerability, and 30th for flood-related disasters (UNDP, 2004). The devastating impacts of recent natural disasters, including the 2015 Gorkha earthquake and recurrent monsoon-triggered events, further underscore the urgent need for effective disaster risk reduction and resilience-building measures across the country.

The Gorkha District, located in the Gandaki Province of central Nepal, is particularly vulnerable to these hazards due to its mountainous terrain and proximity to major river systems (Poudel et al., 2020). Gorkha was the epicenter of the 2015 earthquake, and since then, disaster risk reduction and resilience have become a central concern (UNDP, 2021).

Palungtar Municipality, a rapidly urbanizing area within Gorkha, has experienced increasing environmental stress due to changing land use patterns, deforestation, and climate variability. Seasonal landslides and floods are common, especially during the monsoon season, and wildfires often affect the forested areas in the dry season (NDRRMA, 2022). These hazards are exacerbated by weak infrastructure, scattered settlements, and limited disaster preparedness.

Objectives of the Study

The main objective of this study is to examine the impact of natural hazards specifically fire, flood, and landslides and to explore the state of community resilience in Palungtar Municipality, Gorkha District. The specific objectives are:

- To analyze the occurrence, causes, and impacts of fire, flood, and landslide events in Palungtar Municipality.
- To assess the community's resilience strategies and adaptive responses to these natural hazards.

Methodology

This study employs a qualitative and descriptive case study approach to assess the impacts of fire, flood, and landslide hazards and to evaluate community resilience in Palungtar Municipality, Gorkha District, Nepal. The research combines both primary and secondary sources of data for a comprehensive understanding of hazard patterns and local responses.

Study Area

Palungtar Municipality is located in the southern part of Gorkha District within Gandaki Province, Nepal. Geographically, it lies in the hilly region of central Nepal, extending from 27°56′04″ to 28°25′06″ North latitude and 84°25′30″ to 84°35′25″ East longitude. The elevation ranges from 338 meters to 1,426 meters above sea level, contributing to varied topography and ecological diversity (Figure 1).

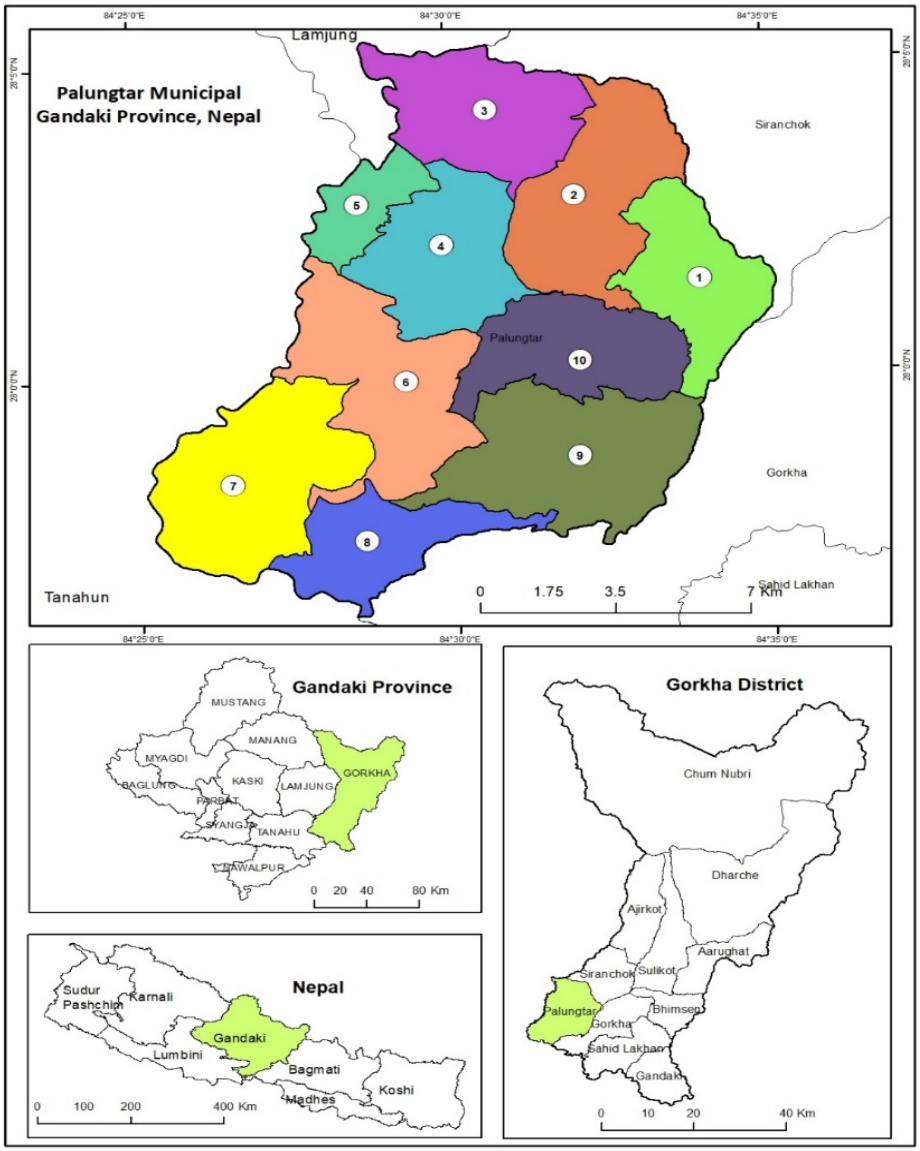
The municipality stretches 12.34 kilometers in width (east-west) and 16.60 kilometers in length (north-south) as the maximum aerial distance. It covers a total area of 158.62 square kilometers, which accounts for approximately 4.39% of the total 3,610 sq. km area of Gorkha District.

Palungtar is prone to multiple natural hazards due to its complex terrain, proximity to river systems, and seasonal climatic variability. Landslides frequently occur during the monsoon season, especially in the northern wards with steep slopes. Flooding is common along riverbanks, affecting

agriculture and settlements, while forest fires are a seasonal concern during the dry months. The municipality comprises both rural and semi-urban settlements, with most residents depending on agriculture and remittance-based livelihoods. These physical and socio-economic characteristics significantly influence the community's vulnerability and resilience capacity.

Figure 1

Location of the study area



Sources of Data

Primary Data

Data were collected through field visits, key informant interviews (KIIs), and focus group discussions (FGDs) with local residents, municipal officials, and disaster response personnel. Observation of affected areas was also carried out to document visible damage and risk-prone zones.

Secondary Data

The set of environmental variables utilized in this study to support the spatial analysis of natural hazards in Palungtar Municipality. These variables, categorized into topographic, climatic, vegetation-related, and anthropogenic factors, were selected based on their relevance to the occurrence and distribution of fire, flood, and landslide events. Topographic variables, including elevation, slope, aspect, and distance to water bodies, were obtained from the United States Geological Survey (USGS, 2019) and Geofabrik (2019). These variables are critical in determining the spatial patterns of landslides, floods, and fire-prone areas. Climatic variables such as mean annual precipitation, temperature, and solar radiation were derived from the WorldClim (2019) database, which provides high-resolution global climate data useful for environmental and hazard modeling. Vegetation-related data, including the mean Enhanced Vegetation Index (EVI) and forest cover, were sourced from MODIS (2019) and the Global Forest Change dataset (Hansen et al., 2013). These variables help assess vegetation health and density, which directly influence the occurrence and spread of wildfires and slope stability in landslide-prone areas.

Analysis

The collected data were analyzed using both qualitative and spatial methods to assess the occurrence and impacts of natural hazards, as well as the level of community resilience in Palungtar Municipality. Descriptive statistics were used to summarize hazard events, socioeconomic impacts, and local coping strategies based on primary data from interviews and field observations.

For spatial analysis, environmental variables were processed in ArcGIS 10.8 to ensure consistent format and resolution. To model hazard-prone areas, the study employed MaxEnt (Maximum Entropy), a machine-learning-based software tool originally developed for modeling species distributions using geo-referenced occurrence data and environmental variables (Phillips et al., 2006). In recent years, MaxEnt has also been effectively used to predict natural hazard risks, including forest fires, floods, and landslides, by identifying the probability of hazard occurrence across a given landscape (Goetz et al., 2011). This approach allowed for the generation of spatial probability maps, highlighting zones with varying levels of hazard susceptibility within the study area.

Results and Discussion

This section presents the key findings of the study regarding the occurrence, causes, spatial distribution, and community responses to natural hazards in Palungtar Municipality. The analysis focuses on three major hazards- fire, flood, and landslide, which were identified as the most recurrent and damaging in the area. The results are based on both qualitative data from field interactions and spatial modeling using MaxEnt (Figure 2).

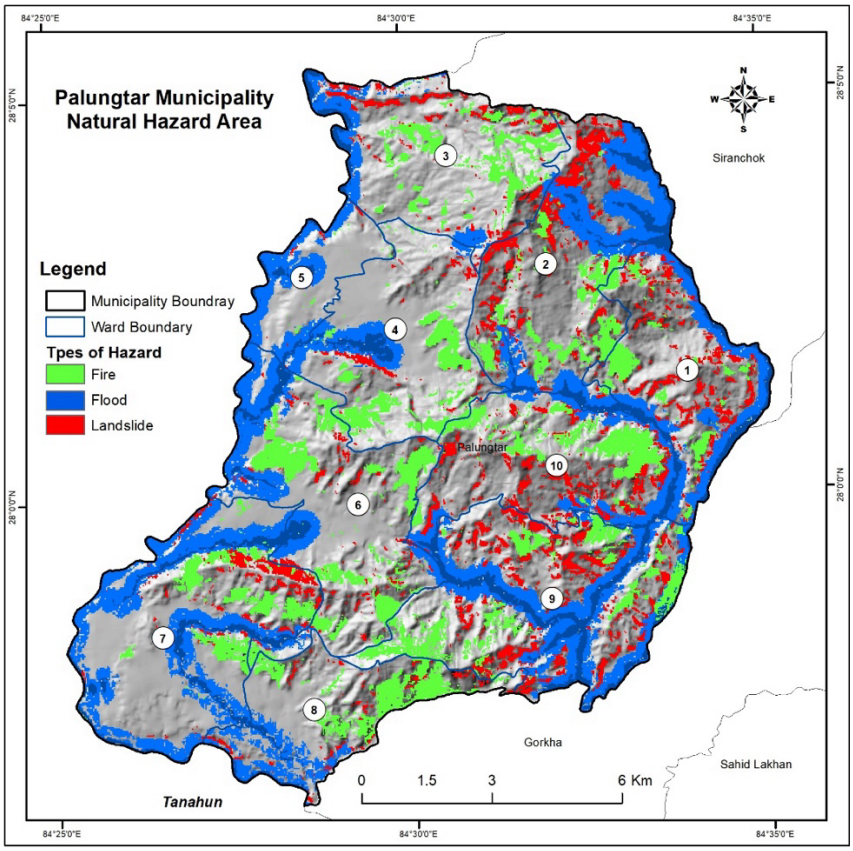
Fire Hazard

Forest fires in Palungtar Municipality occur predominantly during the dry pre-monsoon season, typically from March to May, when vegetation dries out and the risk of ignition increases. According to municipality records and field observations, forest fire incidents are recurrent and often go unreported unless they reach a critical scale. These fires not only degrade forest ecosystems but also threaten agricultural lands and human settlements, especially in forest-adjacent communities.

Based on spatial modeling and analysis using MaxEnt and verified with the hazard map (Figure 2), several high-risk zones for fire have been identified. One of the most affected areas is the forest belt near Aathghare in Ward No. 2, where frequent small-scale fires have been reported, likely due to local grazing and fuelwood collection practices. Similarly, the southern part of Hadikhola in Ward No. 3 experiences periodic wildfires, especially in areas adjacent to human settlements and trails. In Ward No. 6, the forested regions of Pipalthati and Shanetar have also emerged as notable fire-prone zones due to their topographic exposure and unmanaged vegetation buildup. The Dharapani forest area in Ward No. 8 is another critical zone, where fire incidents are often linked to slash-and-burn agriculture and the absence of firebreaks. Likewise, the Mirkot area in Ward No. 10 shows strong fire susceptibility, as indicated by model outputs and local reports.

Figure 2

Natural Hazard Area of Palungtar Municipality



The hazard map of Palungtar confirms these spatial patterns, showing significant overlap between high fire risk zones and forest-dominated landscapes with low moisture content and higher solar radiation. In addition to environmental factors, the proximity of rural paths and the use of open fires for agricultural purposes contribute significantly to ignition risk. Despite the persistence of these hazards, fire preparedness in Palungtar remains limited. There is a lack of fire control infrastructure, trained response teams, and early warning systems at the local level. Most mitigation measures are reactive, relying on manual labor and community-led efforts, which are insufficient for managing fires during peak dry seasons. This underscores the urgent need for structured fire management strategies, capacity building, and awareness campaigns to reduce the increasing risk of forest fires in the municipality.

Flood Hazard

Flooding is a major and recurrent hazard in Palungtar Municipality, particularly during the monsoon season from June to August. The municipality's location at the confluence of several major and minor river systems-including the Daraudi, Marsyangdi, Chepekhola, and Bhusundi-makes it particularly vulnerable to riverine flooding and bank erosion (Figure 2). Based on MaxEnt modeling and field validation, flood-prone zones are concentrated along low-lying river corridors and confluence zones, with significant socio-economic implications for nearby communities.

Ward No. 1 is particularly exposed to flooding from the Bhusundi Khola and Dhundhure Khola, where rising water levels during heavy rainfall events inundate agricultural lands and disrupt local settlements. In Wards 1 and 9, the Daraudi River corridor emerges as a highly flood-sensitive area, where both overbank flooding and sediment deposition pose serious threats to infrastructure and livelihoods. Similarly, the Chepekhola confluence in Ward No. 3 has been identified as another flood hotspot, especially during peak monsoon when tributaries converge with high discharge volumes.

In the western and southern part of the municipality, Wards 5, 6, 7, and 8 are severely affected by the edge cutting and lateral erosion caused by the Marsyangdi River, which frequently alters its course during the rainy season. In particular, the Dovan area of Ward No. 5 and the Satighat area of Ward No. 7 have experienced repeated damage due to riverbank erosion and flash flooding, often resulting in the loss of farmland and temporary displacement of residents.

Despite the recurrent nature of these flood events, structural flood mitigation efforts in Palungtar remain minimal. Some embankments and gabion walls have been constructed in highly exposed areas, but these are often temporary and inadequate against extreme events. Early warning systems are not consistently functional across all wards, and coordination between municipal authorities and local communities during flood emergencies is still evolving. These findings highlight the need for integrated river management, flood-resilient infrastructure, and the strengthening of local response capacities to mitigate flood risk in the municipality.

Landslide Hazard

Landslides are one of the most frequent and destructive hazards in Palungtar Municipality, especially during the monsoon season when intense rainfall triggers slope failures across steep and unstable terrain. The municipality's hilly topography, weak geological formations, unregulated road construction, and deforestation have collectively increased the likelihood of landslides in recent years

(Figure 2). According to the hazard map and field-based validation, several locations within Palungtar are identified as high-risk zones for landslide events.

One of the most severely affected areas is the edge-cutting zone along Dharadi Khola, where continuous fluvial erosion weakens the surrounding slopes, making them highly prone to failure during heavy rainfall. Similarly, settlements like Karki Gaun and Simpani are located on steep inclines with loose soil and poor drainage, contributing to shallow and deep-seated landslides. In the Bhandarthok area, repeated slope collapses have caused damage to foot trails, agricultural terraces, and rural dwellings, with some families forced to relocate seasonally.

Other high-risk locations include the Chharek area, where unplanned rural roads have destabilized natural slopes, and the Khorkhola and Dhard Khola areas, which are characterized by fragile terrain and concentrated rainfall. These locations show a clear spatial overlap with high slope gradients, weathered rock layers, and human disturbances—factors that were emphasized in the MaxEnt analysis as critical drivers of landslide risk.

While some local efforts have been made to manage minor landslides using gabion walls, stone pitching, and vegetation planting, large-scale and recurring landslide threats remain unaddressed. There is limited geotechnical assessment, and mitigation strategies are reactive rather than preventive. Additionally, public awareness of landslide early warning signs is low, and evacuation planning is minimal. This highlights the pressing need for slope stabilization measures, sustainable land use practices, and community-level capacity building to effectively reduce landslide risk in Palungtar Municipality.

Community Resilience to Natural Hazards

Community resilience in Palungtar Municipality is shaped by a combination of local knowledge, traditional coping mechanisms, social networks, and institutional support. Despite facing recurring hazards such as fire, flood, and landslides, communities in Palungtar have demonstrated adaptive behaviors developed over generations. For instance, during flood events, residents living near riverbanks often elevate their homes, store dry food in upper levels, and construct temporary barriers using sandbags (ICIMOD, 2021). Similarly, in landslide-prone areas, farmers practice terrace farming and plant deep-rooted vegetation to stabilize slopes (UNDP, 2021). In the case of forest fires, informal community groups frequently mobilize to contain the spread using manual tools and firebreaks, although these efforts remain largely uncoordinated and resource-constrained (MoFE, 2020).

Institutionally, local disaster management committees (LDMCs) have been formed in some wards under the framework of the Local Disaster and Climate Resilience Planning (LDCRP) process, introduced by the National Disaster Risk Reduction and Management Authority. These bodies are responsible for preparing basic risk assessments and mobilizing resources during emergencies (NDRRMA, 2022). However, their effectiveness varies across wards due to uneven capacity, lack of training, and limited funding (UNDRR, 2019). Non-governmental organizations and external development partners have also supported disaster risk reduction through school-based awareness programs, simulation exercises, and construction of basic mitigation infrastructure such as check dams and gabion walls (UNDP, 2021).

Despite these efforts, significant challenges persist. Early warning systems are either absent or underutilized, and communication during disasters remains fragmented (MoHA, 2020). Many vulnerable households lack access to insurance, safe shelters, or emergency health services. Moreover, the increasing intensity and unpredictability of climate-induced hazards have started to outpace traditional coping capacities. Strengthening resilience in Palungtar thus requires not only improved infrastructure and early warning systems but also investment in education, inclusive governance, and integration of indigenous knowledge with modern disaster management practices. Building adaptive capacity at the household and community level is essential to ensure that local populations can prepare for, respond to, and recover from natural hazards more effectively (ICIMOD, 2021; UNDRR, 2019).

Conclusion

This study has provided an empirical assessment of natural hazards and community resilience in Palungtar Municipality, Gorkha District, Nepal. By integrating field observations, spatial modeling using MaxEnt, and qualitative interviews with local stakeholders, the research identified fire, flood, and landslides as the three most prevalent hazards affecting the region. Each hazard exhibits unique spatial patterns and seasonal behaviors influenced by topography, climatic conditions, and anthropogenic activities.

Forest fires were found to be most common during the pre-monsoon season and concentrated in areas such as Aathghare, Hadikhola, Pipalthati, Dharapani, and Mirkot, where vegetation is dense and fire management practices are lacking. Flood-prone zones were mapped along the corridors of the Daraudi, Marsyangdi, and other river systems, with significant impact recorded in Bhusundi Khola, Dovan, and Satighat. Landslides, primarily triggered by intense rainfall and slope instability, were most severe along Dharadi Khola and in settlements such as Karki Gaun, Bhandarthok, and Chharek. The MaxEnt model confirmed strong correlations between these hazards and environmental factors such as elevation, slope, vegetation index, and proximity to rivers and human settlements.

Community resilience, though present in various traditional and institutional forms, remains uneven across the municipality. Households have developed localized coping strategies such as terracing, elevated storage, and manual fire control. However, the capacity of local disaster management committees is limited by inadequate resources, technical know-how, and a lack of coordination. The absence of robust early warning systems and risk-sensitive development planning continues to expose vulnerable populations to recurring losses.

The findings underscore the need for targeted, area-specific interventions that combine scientific hazard mapping with community-led preparedness and mitigation efforts. Strengthening institutional frameworks, integrating local knowledge into planning, and investing in risk reduction infrastructure are essential for enhancing resilience in Palungtar. Overall, this case study offers valuable insights into the complex interplay between natural hazards and local adaptive capacity in a hazard-prone, resource-constrained Himalayan setting.

References

Gautam, D., Thapa, S., Pokhrel, S., & Lamichhane, S. (2021). Local level multi-hazard zonation of Nepal. *Geomatics, Natural Hazards and Risk*, 12(1), 405-423.

Geofabrik. (2019, 05 20). Geofabrik. Retrieved from www.geofabrik.de: https://www.geofabrik.de/data/shapefiles.html.

Goetz, J., Guthrie, R., & Brenning, A. (2011). Integrating physical and empirical landslide susceptibility models using generalized additive models. *Geomorphology*, 129, 376-386.

Hansen, M., Potapov, P., Moore, R., Hancheer, M., Turubanova, S., Tyukavina, A., et al. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, 342, 850-854.

ICIMOD. (2019). *ICIMOD Portal*. Retrieved from www.icimod.org: http://www.icimod.org

ICIMOD. (2021). *Community-based Disaster Risk Reduction in the Hindu Kush Himalaya*. International Centre for Integrated Mountain Development. https://www.icimod.org

Ministry of Home Affairs [MoHA]. (2020). *Nepal Disaster Report 2019: The Road to Sendai*. Government of Nepal. https://www.moha.gov.np

MODIS. (2019). *NASA/Moderate Resolution Imaging Spectroradiometer*. Retrieved 2019, from https://modis.gsfc.nasa.gov/

MoFE. (2020). *Nepal Second National Communication to the UNFCCC*. Ministry of Forests and Environment, Government of Nepal.

MoHA. (2020). *Nepal Disaster Report 2019: The Road to Sendai*. Ministry of Home Affairs, Government of Nepal.

National Disaster Risk Reduction and Management Authority [NDRRMA]. (2022). *Disaster Risk Profile of Nepal*. https://www.ndrrma.gov.np

NDRRMA. (2022). *Disaster Risk Profile of Nepal*. National Disaster Risk Reduction and Management Authority. https://www.ndrrma.gov.np

Phillips, S.B., V.P. Aneja, D. Kang, & S.P. Arya. (2006). Modelling and analysis of the atmospheric nitrogen deposition in North Carolina. *International Journal of Global Environmental Issues* 6: 231–252. https://doi.org/10.1016/j.ecolmodel.2005.03026.

Poudel, K. R., Hamal, R., & Paudel, N. (2020). Landslide Susceptibility Assessment: Identification and Hazard Mapping of Gandaki Province, Nepal. Prithvi Academic Journal, 3(May), 11–21.

UNDP. (2004). "Reducing Disaster Risk: A Challenge for Development." New York.

UNDP. (2021). *Building resilience in earthquake-affected areas of Nepal: Lessons from Gorkha*. United Nations Development Programme. https://www.undp.org/nepal

UNDRR. (2019). *Disaster Risk Reduction in Nepal: Status Report 2019*. United Nations Office for Disaster Risk Reduction. https://www.undrr.org

USGS. (2019, May 02). *Earth explorer*. Retrieved from Earth Explorer: https://earthexplorer.usgs.gov

WorldClim. (2019, 5 10). *WorldClim database*. Retrieved from www.worldclim.org: http://worldclim.org