CHAPTER 1
INTRODUCTION

1.1 Background and Rationale

Hazard simply means as a condition of a potential harm. In many environmental literature, the term 'hazard' and 'risk' used simultaneously to describe those activities which are threats to human lives properties and the surrounding environment. The analysis of risk-hazard will increase the level of awareness and knowledge for decision makers. It also provide a picture of the risk and vulnerability that may exist in our society, which supports to make threat mitigation plan or safety preparedness plan.

Land use planning is a tool to reduce potential risk from natural or manmade hazards. **Man-Made Hazards** are the events caused by humans and occur in or close to human settlements whereas **natural hazard** refers to all atmospheric, hydrologic and geologic phenomena that have potential to affect human beings, their structures, and/or activities adversely (Burton, Kates and White, 1978). Land use planning without due consideration these hazards/risks are not effective. Mainstreaming disaster risk reduction in land use planning can systematically reduce impact of specific hazard. There exist diversities in risk type such as fire, flood, landslide, seismic, industrial etc. The government of Nepal has enacted the Land Use Act 2076. The Act has encouraged to make different land use zones (see Paragraph- 2(4) through the analysis of geology, land capacity and suitability, present land use and as per necessity. The Act has also provisioned of federal, provincial and local level land use council and their roles and responsibilities for effective implementation of land use policy and plans (see Paragraph-4). Land use policy 2072 (policy 13) has also focused on the development of land use planning information system through the preparation of land use/land resources maps, land capability maps, hazards maps and generated database. The policy assumed that the preparation of land use zoning through the analysis of hazard risk will be more suitable to secure people's lives and properties and conducted related activities. Therefore, the main objective of this study is to investigate the risk factor associated with the land use planning.

1.2 Objectives of the Study

Disaster risk layer is considered as a key components for the preparation of land use zoning maps and database. For this purpose fire, flood, landslide, industrial and seismic hazards are taken into consideration. Depending on the nature of disaster their inputs, objective, scope, method and output varies. Therefore, the general objective of this study is to identify the risk events potentially caused by flood, landslide, earthquake, fire and industry within the study areas; and prepare a risk map and GIS database at 1:10,000 scale which is required for preparation land use zoning of **Bareng Gaunpalika** of Baglung District (Package-03) (fiscal year 2075/76).

1.3 Study Area

Bareng Gaunpalika lies in Baglung district of Gandaki province. Five Village Development Committees (VDCs) namely: Dhullubaskot, Hugdishir, Salyan, Batakachaur and Surkhaura have been merged and formed Bareng Gaunpalika after the constitution of Nepal in 2072 B.C. The Gaunpalika is bordered by Jaimuni Gaunpalika to the east, Galkot Nagarpalika and Gulmi district to the west, Galkot Nagarpalika and Jaimuni Gaunpalika to the north and Gulmi district to the south (figure 1.1). It covers a total area of 75.28 sq km.

Administratively, Bareng Gaunpalika has 5 wards. According to the CBS (2011), there were 3,207 households with a total population of 14,519. Of the total population, the percentage of male is 3 percent lower than female. In terms of area and population, all wards have different in size. Ward number one has the largest population size of 3,915 and ward number five has smallest population size of 1,214. The average household size of the Gaunpalika is 4.5 which is slightly lower than the national average (4.88).

Bareng Gaunpalika has inhabitants of different caste/ethnic group. The majority is Magar (38.7%) which is followed by Dalit and Chhettri (26.1% and 18.8%) respectively. The literacy rate of the Gaunpalika is 86.5. This rate is higher than average literacy rate of Nepal. Bareng Gaunpallika largely depends on agriculture/livestock farming. Agriculture, remittances and business are the major source of income.

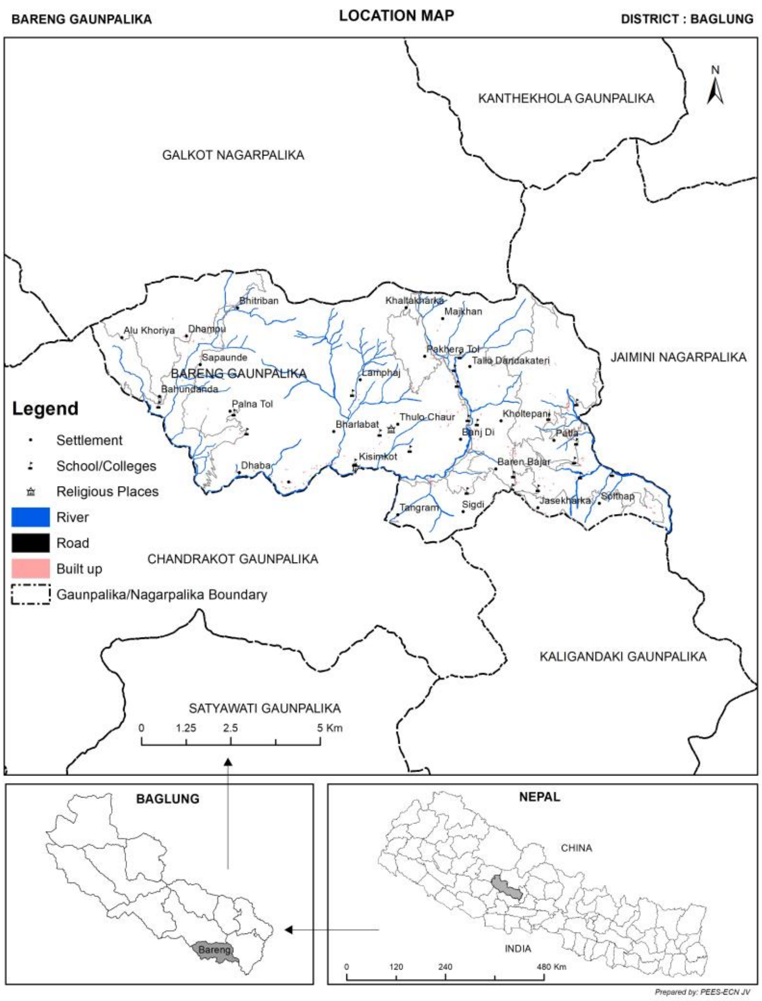

Figure1.1: Location of Bareng Gaunpalika

CHAPTER 2
CONCEPTUAL BASIS OF RISK MAPPING

2.1 Risk and its relation to Land Use Zoning

Planning has the greatest chance to reduce risk. Land-use planning is considered one of the best practices for the disaster risk management, by which a community can consider disaster risks and their spatial distribution, steer more sustainable land development and use, and reduce the vulnerability of poor people who are often settled on degraded sites with significant risks and constraints (Roy and Ferland, 2015). Recently, in many countries, integration of disaster risk into spatial planning has been largely emphasized. Spatial planning requires hazard information, and hazard information is needed by planners to decide which areas should be prohibited for future development due to excessive risks or to allocate land for potential uses on the basis of hazard intensity or recurrence interval. In this context, land use planning is recognized not only as a key for achieving sustainable development but also as a tool to mitigate risks, generated due to natural and manmade disaster. Greiving and Fleischhauer (2006) discussed various aspects of the integration between risk and spatial planning. Fleischhauer et al. (2006) have also identified four possible roles of spatial planning in risk management namely;

- Keeping areas free of future development that are; a) hazard pone, particularly with history of occurrence of disaster events, b) needed to lower the effects of hazardous event (e.g. flood retention basins), and c) needed to enhance effectiveness of disaster response (e.g. evacuation routes etc).
- Differentiated decisions on land use – allocating land for different uses based on hazard intensity, frequency or other hazard criteria. For instance flood prone areas may be used for agriculture purposes and may be forbidden for residential or siting of critical buildings, avoiding construction on steep slopes but encouraging forestation on those areas etc.
- Regulating land use by legally binding status – for instance regulating building density in earthquake prone areas, recommended roof types for buildings in the hurricane belt, or prohibition of basements in flood prone areas.
- Hazard modification - spatial planning can contribute in reduction of hazard potential of some of the natural hazards such as floods. This can be achieved by influencing intensity and frequency of a hazard.

(Source: Spatial planning and Hazard Data Requirements, ACE-EU Natural Disaster Risk Reduction Programme. Retrieved from www.charim.net/methodology/71,cited in NLUP, 2074.

Population, buildings and infrastructure, economic activities, public services utilities, other infrastructures and environmental values in the area potentially affected by the hazard are deemed as elements at risk. The assets at risk from disaster can be enormous and include private housing, transport and public service infrastructure, commercial and industrial enterprises, and agricultural land. FAO's Guidelines for Land Use Planning (1989, 1993) make it clear that in the long run, land use must be economically viable and socially acceptable, and that one major goal of development planning is to make an efficient and productive use of the land. In this context, hazard and risk factor must be analyzed while preparing land use planning/zoning. Land use zoning refers to the division of land into homogeneous areas and their ranking according to degrees of actual or potential hazard or risk or applicability of certain hazard-related regulations; and modern land use planning has also emphasized to environmental component, and in this respect it is often restrictive in the kind of land uses permitted (Verheye 2009; Xue Dongqian, Ma Beibei, Zhang Xiaojun 2006).

2.2 Relation of vulnerability and hazard with Risk

Hazard: hazard refers to the possible, future occurrence of natural or human-induced physical events that may have adverse effects on vulnerable and exposed elements (White, 1973; UNDRO, 1980; Cardona, 1990; UNDHA, 1992; Birkmann, 2006b; cited in Omar-Dario Cardona, Maarten K. van Aalst et.al. available at https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap2_FINAL-1.pdf). It is a condition for causing an undesirable consequence, which expressed as the probability of a potentially damaging event of a certain magnitude occurring within a certain period of time. Hazards depends on site-specific and seasonal climatic conditions. For example, the description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the probability of their occurrence within a given period of time. Sometimes, hazard has been ascribed as a synonyms of risk, but it is a component of risk and not risk itself.

The initiating causes of a hazard may be either an external (e.g. earthquake, flood or human agency) or an internal (defective element of the system e.g. an embankment breach) with the potential to initiate a failure mode. Hazards are also classified as either of natural origin (e.g. excessive rainfalls, floods) or of man-made and technological nature (e.g. sabotage, deforestation, industrial site of chemical waste). Regarding hazard identification and estimation, two approaches can be identified based on the ANCOLD Guidelines (2003) and the ISDR principles (2004):

a. Traditional deterministic approach: a first level estimation of the potential adverse consequences, if the hazard occurs, in order to classify the system under threat, identify the necessity or not of further investigation. This approach is also the most comprehensive way of estimating man-induced and /or technological hazards, e.g. a forest fire hazard that cannot be captured by a probability distribution.

b. Probabilistic approach: it is based on the theory of probability and regards hazard estimation as the estimation of the probability of occurrence of a particular natural event with an estimated frequency within a given period of time. It can be applied on hazards of natural origin and it represents a very common method used in most flood plain delineation studies when the potential for loss of life is considered negligible in terms of historical floods. The probabilistic approach tends to assume that events in the future are predictable based on the experience of the past.

Vulnerability: One of the best-known definitions of vulnerability was formulated by the International Strategy for Disaster Reduction (ISDR, 2004), which regards it as “a set of conditions and processes resulting from physical, social, environmental and economical factors, which increase the susceptibility of a community to the impact of hazards”. It can be seen as situation-specific, interacting with a hazard event to generate risk (Lavell, 2003; Cannon, 2006; Cutter et al., 2008; cited in Omar-Dario Cardona, Maarten K. van Aalst et.al. available at https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap2_FINAL-1.pdf)).Therefore, vulnerability is:

- Multi-dimensional and differential (varies across physical space and among and within social groups).
- Scale-dependent (with respect to time, space and units of analysis, such as individual,

household, region, system).

- Dynamic (characteristics and driving forces of vulnerability change over time, certainly exceeding that time of the extreme event itself). (Bohle, 2001).

The vulnerability function could be treated as a function between 0 and 1. However, the most appropriate approaches for the case of vulnerability of the society and the cultural heritage are thought to be qualitative. A vulnerability analysis in the event of a hazard like flood considers the population and structures at risk within the affected area. In the start of the analysis, a reference level of the system's vulnerability should be determined that usually refers to existing flood protection systems of the affected area. The vulnerability analysis evaluates the potential costs of disaster event in terms of damages to buildings, crops, roads, bridges and critical infrastructure etc.

Risk is defined as the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions (UN-ISDR, 2009, EC, 2011 cited in Westen, n.d). Risk can presented conceptually with the following basic equation.

*Risk = Hazard * Vulnerability * Amount of elements-at-risk*

The equation given above is not only a conceptual one, but can also be actually calculated with spatial data in a GIS to quantify risk from geomorphological hazards. The way in which the amount of elements-at-risk are characterized (e.g. as number of buildings, number of people, economic value) also defines the way in which the risk is presented.

The relationship between risk, hazard and vulnerability has been presented in figure 2.1

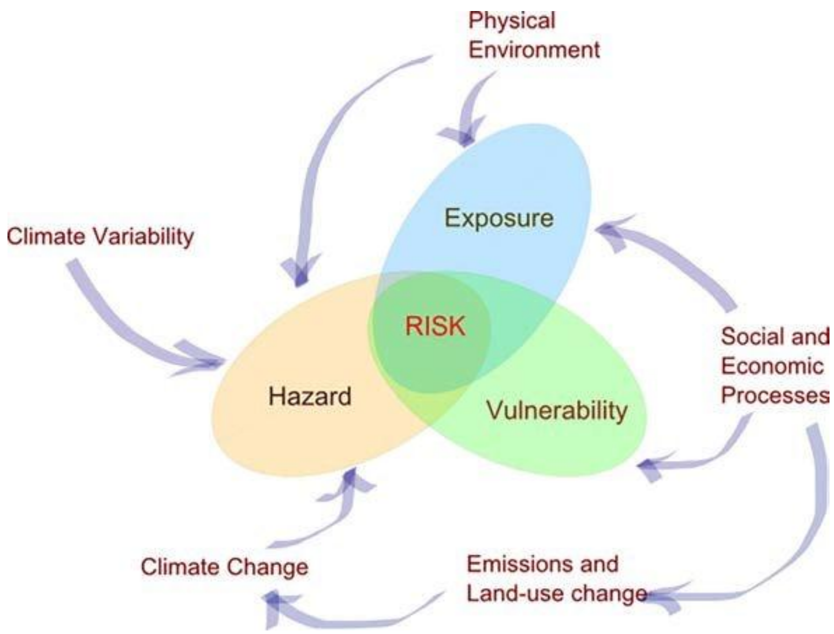

Figure 2.1. Factors of Disaster

Source:https://www.researchgate.net/figure/Relationship-between-the-physical-climate-system-hazard-exposure-and-vulnerability_fig1_324770994 [accessed 10 Nov, 2019]

2.3 Risk types and their Descriptions

Depending upon the types of factor causing an area to expose into vulnerability and hazard associated with it, risk can be classified into various categories. However, for the land use mapping process, risk factors have been specified related to the following events: Flood, Landslide, Soil erosion, Fire, Earthquake (Seismic event) and Industrial hazard.

Flood: A flood is an overflow of water. It usually occurs in rivers when the flow rate exceeds the capacity of the river channel. Moving water has awesome destructive power when a river overflows its banks. Country like Nepal, there is high potentiality of flash flood (rapid flooding event), erosion and inundation particularly during the monsoon season. Nepal has more than 6000 rivers and rivulets (Manandhar, 2010). These rivers and rivulets support irrigated agriculture and other livelihoods, but also wreak havoc in valleys and in the terai when they overflow (Dixit, 2010). This phenomenon occurs mainly in Monsoon. Intense monsoon rainfall causes flooding in many rivers of Nepal. The frequency of flood and scale of damage have increased in the terai and inner terai regions of Nepal. Thousands of people are affected by flood every year in Nepal during the monsoon season.

According to EU Directive (COM, 2006) for flood management, "flood risk" is the likelihood of a flood event together with the actual damage to human health and life, the environment and economic activity associated with that flood event. In this context flood risk can be considered as the actual threat, in other words the real source of flood hazard to the affected areas. The quantification of flood risk results either in monetary units or in loss of life units, if the losses are measurable, or in qualitative terms (e.g. allocation in classes) in the case of intangible damages (social, environment, cultural) to the affected areas. In general, risk as a concept incorporates the concepts of hazard {H} (initiating event of failure modes) and vulnerability {V} (specific space/time conditions). Mathematically, it is expressed risk (R) as a functional relationship of hazard (H) and vulnerability (V); $R = \{H\} \times \{V\}$.

<u>*Floods in Nepal:*</u> Flood occurs repeatedly in low plains of Nepal causing loss of lives and properties. Nepal has more than 6000 rivers and rivulets (Manandhar, 2010). Major sources of water are Glaciers Rivers, lakes, rainfall, ponds, groundwater etc. Intensity of rainfall with average 1700 mm annually contributes to surface water flow in average annually of approximately 224.7 billion m^3 or in terms of flow rate; it is 7,125 m^3/sec (Bajracharya and Mool *et al*., 2009). It further adds that Nepal suffers from frequent water induced disaster like flood, landslide, erosion, debris flows, glacial lake outburst, drought and epidemic. This phenomenon occurs mainly in Monsoon. Intense monsoon rainfall causes flooding in many rivers of Nepal; and water induced disasters causes average annual loss of 309 lives and affects 27654 families (Baracharya and Mool *et al*., 2009). Nepal Disaster Report (2019) reported that 213 people were died, 16734 family were affected, and 15155 houses were destroyed (partial/complete) in 2017/18 due to floods and heavy rainfall in Nepal (MoHA, 2019).

Landslides: Landslides are a form of erosion and are an important process in the shaping and reshaping landscapes and landforms. Landslide hazard is frequent phenomenon is Nepal due to several reasons including tectonic activities, uncontrolled and unsafe development, heavy precipitation and environmental degradation. However it is observed that rainfall induced landslides is most prevalent in the hills and mountainous districts. Landslide susceptible area of varying degree, potential landslides may be of varying likelihood of occurrence based on management practices and protection measures in the area. In Nepal, high susceptibility zone of landslide are identified in the areas of high intensity rainfall and earthquake hazard. Nepal Disaster Report (2019) reported that 161 people were died, 1083 family were affected, and 479 houses were destroyed (partial/complete) in 2017/18 due to landslides in Nepal (MoHA, 2019).

Fire: Fire is common event every year in Nepal, particularly in the settlements of Terai and forests in hills region of Nepal. Government of Nepal has given less priority in managing settlement and/or forest fire due to limited resources. It is common in Terai during the dry, stormy season between April and June when temperatures exceed 35°C, houses in the region are wooden and have thatched roofs, they are extremely vulnerable to incendiary lighting strikes, suffers from numerous fire outbreaks mainly during the process of cooking. In the winter, the major cause of fires is the short circuiting of electrical appliances, particularly heaters. In urban and other areas, houses are built in close proximity; these too are vulnerable, as fires easily leap from one house to the next. This fires cause great loss of life and property and can have a devastating impact on local economies.

Very few fires are naturally caused in Nepal (NBS, 2002). Karkee (1991) observed that 40percent of forest fires in the mid-hills are caused by accidents while 60percent are started deliberately e.g. Shifting cultivation, forest encroachment. In settlement areas, due to negligence while cooking, firing is common house and shelter. Faulty wiring and electrical equipment, candles, home heating and cooking, children activities, flammable liquids (fuels, solvents, adhesives, paints, and other raw materials – can ignite or explode if stored improperly) and careless smoking were the main sources of firing in houses and settlements areas. According to the Nepal Disaster Report (2019) reported loss of 150 people were died, 6027 family were affected, and 3783 houses were destroyed (partial/complete) in 2017/18 due to fire in Nepal (MoHA, 2019).

In an industrial area the fires occur when hazardous materials such as petrochemicals spill or leak and subsequently explode, technology fails, vehicles collide, and factories catch on fire. Within minutes, an entire industrial area can be aflame and billions of rupees of property swallowed up. They also take lives and destroy the environment.

Earthquake (Seismic event): Earthquake or seismic event is the sudden shaking of the earth surface. Its magnitude is measured by Richter scale ranges between 0-9. An earthquake of magnitude above 7 is considered as a big earthquake. The Himalaya seismicity owes its origin to the continued northward movement of Indian plate after the continental collision between Indian plate and Eurasian plate. The magnitude, recurrence and the mechanism of continental collision depend upon the geometry and plate velocity of Indian plate in relation to southern Tibet (Eurasian Plate). Recent studies also suggest that the convergence rate is about 20 mm / year and the Indian plate is sub-horizontal below the Sub- Himalaya and the Lesser Himalaya. The result of micro seismic investigation, geodetic monitoring and morphotectonic study of the Central Nepal has depicted that the more frequent medium sized earthquakes of 6 to 7 magnitude are confined either to flat decollment beneath the Lesser Himalaya or the upper part of the middle crustal ramp. The ramp is occurring at about 15 km depth below the foothills of the Higher Himalaya in the south of MCT surface exposures. Big events of magnitude greater than eight are nucleated near the ramp flat transition and ruptures the whole ramp-flat system up to the blind thrust (MBT) of the Sub-Himalaya (Pandey et. al., 1995). According to Bajracharya (1994), Nepal has been divided into five seismic zones (Zone1, Zone 2, Zone 3, Zone 4, Zone 5) with relation to the seismic hazard (Low, Moderate and High). The study area falls in the seismic medium hazard area

(Seismic zone 3) of the Nepal Himalaya.

The Richter scale shows the how big earthquake is, and their hazardous impacts are decided on the basis of quantum of damage or loss of lives and properties. An earthquake becomes a hazard when it strikes in the urban area or the highly populated areas. Loss lives and properties, damage infrastructure and other man made structure, slope failure, decreasing underground water table, drought etc. are direct impacts of the seismic event.

Industrial Hazards: The adverse impacts caused by industrial pollution and expansion within the zone needs to be identified and assessed to conserve the environment, living organism, as well as the biodiversity of the region for promoting the sustainable development of the surrounding communities in a deliberate and tactful way. The major risk area has to be identified so that the proper planning for settlement and other development activities can be done in planned and sustainable way followed by land use planning. The area nearer to the industries are in high risk in all aspect such as health, environmental, water ecology, agricultural productivity etc.

The risks from the industries in Bareng Gaunpalika are minimally negative in nature and low in magnitude as none of the industries are of large scale. As stated above, the majority of the small scale industries are agro based. The agro based industries generate effluents and solid wastes that need to be disposed in an environmentally acceptable manner. However, there is a marginal risk of air pollution and water contamination from wastewater generated by those industries as the industrial discharges end up in surface water, causing a risk on flora and fauna, as well as on human beings, who use the surface water.

CHAPTER 3
METHODOLOGY

3.1 Flood Risk

In natural stream, when quantity of water increased sufficiently, it is said to be flood. Flood is a natural event of rising water level in a stream, lake, reservoir or coastal region (Friesecke, 2004). Flood is too much water in the '*wrong*' place (Singh et al., 2014). A flood is caused by heavy rainfall during short period of time that causes river/oceans to over flow. Flood can happen very quickly when heavy rain falls over a short period of time. Such type of flood is called flash flood, which can occur with little or no warning. This can cause huge damage of human life. The flooding can be worst if storms, 'spring tides' and low atmospheric pressure occur at a time. Floods can distribute large amounts of water and suspended sediment over vast areas, restocking valuable soil nutrients ruining crops, destroying agricultural land and buildings and drowning farm animals (Singh et al., 2014).

Natural hazard due to flood events is a part of nature that is always existed. Floods are climatological phenomena, which are influenced by geology, geomorphology, relief, soil, and vegetation conditions. Meteorological and hydrological processes can produce flash floods or more predictable, slow developing floods causing riverside floods. In some cases, floods are invited by the failure of dam and landslides. Mitigation and non-structural measures are found to be more effective and long-term solution for the river water related problems. The local flood protection measures create negative effect in both upstream and downstream. Therefore, whole river basin should be taken into account. Flood plain should be identified before assigning any land use in such area (UN/ECE, 2003). The identification of flood plain can be performed by delineating flood hazard areas on the map. This can be helpful to keep away the building development in immediate flood risk areas.

Mathematical Method of Flood Risk

According to the EU directive for flood management (COM, 2006), "flood risk" is the likelihood of a flood event together with the actual damage to human health and life, the environment and economic activity associated with that flood event. In this context flood risk can be considered as the actual threat. The flood risk effects can be measured either in monetary terms or in loss of life terms, or in qualitative terms (*e.g.* allocation in classes) in the case of intangible damages (social, environment, cultural) to the affected areas. In general, risk as a concept incorporates the concepts of hazard {H} (initiating event of failure modes) and vulnerability {V} (specific space/time conditions). It is customary to express risk (R) as a functional relationship of hazard (H) and vulnerability (V).

$$\{R\} = \{H\} \text{☼} \{V\}$$

Where, the symbol ☼ represents a complex function incorporating the interaction of hazard (H) and vulnerability (V). Consequently, in mathematical terms it can be expressed as:

$$R = \{H\} \times \{V\}$$

Since vulnerability is a dimensionless quantity (Villagran, 2006) and therefore, risk can be measured in the same units as hazard. In quantitative terms, annualized risk can be estimated as the product of probability of occurrence of the hazardous phenomenon and the actual consequence, combined over all scenarios. According to the method of estimating average (annualized) hazard, the expected value of flood risk can be calculated as follows:

$$E(X) = \int^{\infty} x \,.\, V(x).\ f(x)dx$$

Where *X* is the actual flood damage caused by the flood hazardous phenomenon, *f(x)* is the probability density function (*pdf*) that describes the phenomenon and *V(x)* is the vulnerability of the system towards the corresponding magnitude of the phenomenon. While estimating the flood risk, it involves major restrictions such as:

- It can be applied only on hazards of natural origin due to probabilistic analysis
- As it abides to a general methodological framework , it is highly case specific
- It is highly dependable on expert's judgment

3.1.1 Data

Data for the flood risk assessment can be classified into various groups as follows:

- Land use and land cover
- Elevation data (such as spot height, contour, digital elevation model, etc.)
- Hydrologic parameters (such as catchment area, cross-sectional at defined interval, river bank lines, flow path geometry, stream centre line, etc.)
- Discharge at strategic points
- Soil type and flood plain property (such as manning's constant, river boundary delineation, etc)

The data on those aspects stated above were collected during the field visit done.

3.1.2 General Approach and Methodology Framework

In Nepal, there are various methodological frameworks in practice for flood modeling. It is generally accepted that *the flood risk management framework* should be mainly oriented towards non-structural measures (e.g. land use planning, flood warning systems, evacuation plans, insurance policy). They are mainly driven by the need of cultural heritage protection and also by the socioeconomic conditions of the area concerned. In this context, the methodological framework adopted for the flood risk assessment in this study is shown in Figure 3.1.

In the context of flood risk, the concepts of hazard, vulnerability and risk have been extensively used in various disciplines with a different meaning, impeding cross-disciplinary cooperation for facing hazardous events. Flood, a common natural hazard, has also hard to find the unique definitions and assessment procedures. In this study, it is used a comprehensive way for defining and assessing flood risk and vulnerability in the flood-prone areas. The suggested methodology follows a three-step assessment approach:

i. Annualized hazard incorporating both probabilities of occurrence and the anticipated potential damages
ii. Vulnerability (exposure and coping capacity) in the flood-prone areas, and
iii. Annualized flood risk (estimated on annual basis).

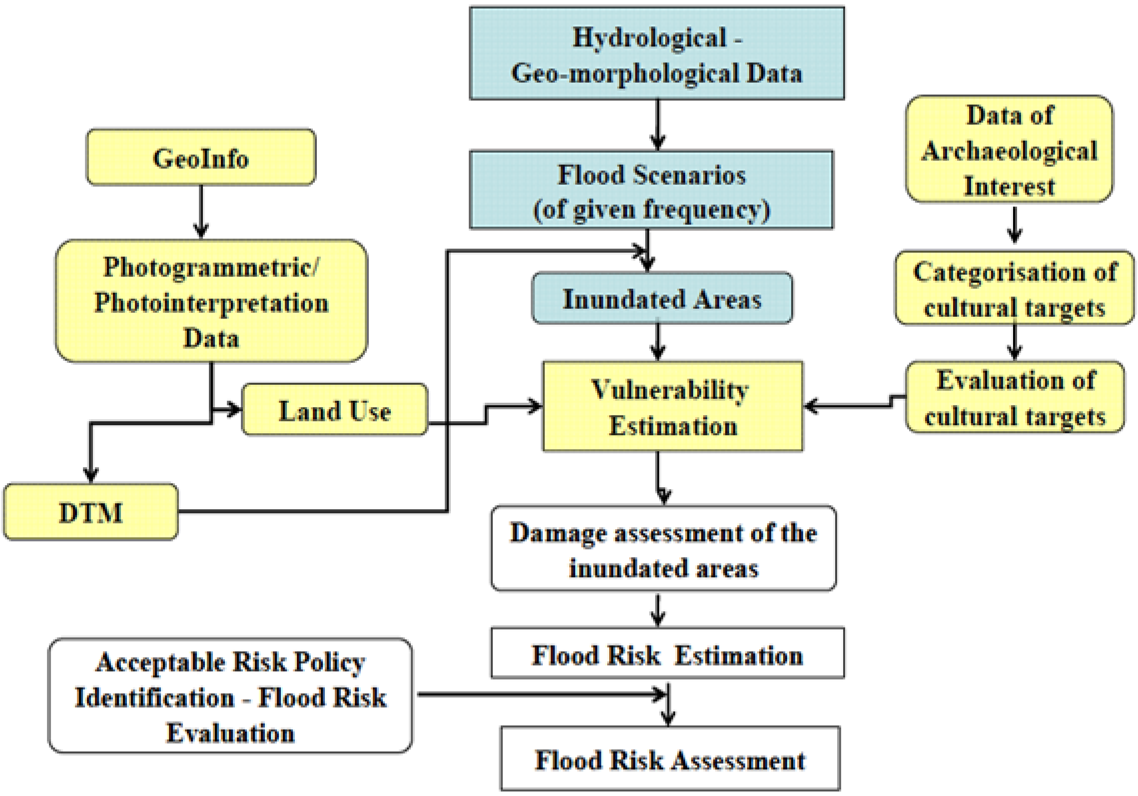

Figure 3.1: Methodological framework for flood risk assessment

The methodology aims to assist water managers and stakeholders in devising rational flood protecting strategies. To apply the methodology, terms such as flood plain, flood hazard map, flood modeling etc are defined with data sources in the following sub-sub sections.

i. Flood plain

The land that lies next to the river or along the river side during normal river flow and submerged during the flood is called as 'flood plain' (Shahiriparsa & Vuatalevu, 2013).

ii. Flood hazard mapping

Flood hazard mapping (FHM) refers to the map that provides information on inundation like predicted inundation, inundation depth etc. This also includes the evacuation routes graphically in understandable format. Flood hazard mapping is an example of non-structural measures for minimizing risk (Konecny *et al*., 2003). FHM includes the information on historical as well as potential future flood events. This can be the basis for determining land use control, flood proofing of constructions and flood awareness and preparedness. FHM provides information on type of flood, the flood extent, water depths or water level, flow velocity or the relevant water flow direction (Prinos, 2009). Flood hazard mapping should be considered before any investments or implementation of development projects.

iii. Flood modeling

It is an engineering tool that provides accurate information regarding flood profile. The governing factor for causing flood are rainfall, run off, catchment characteristics and return period (Singh et. al, 2014). The main input data for calculating flood hazard maps is the occurrence probability and the amount of high water discharge in rivers (Prinos, 2008). Flood discharge calculation is a prominent task for designers of hydraulic structures and river training works. This task is difficult to be adopted as Nepal lacks sufficient hydrological information (Rijal, 2014). To carry out the calculation of flood flow, different approaches can be adopted based on site condition and available data. There are various methods adopted for calculating flood discharges. They are such as rational method, empirical formula (modified Dicken's formula), water and energy commission secretariat (WECS) approach, flood - frequency method, etc. Brief introductions of these methods are given in following sub-sections.

Rational method

The rational method is applied for the peak flow calculation of smaller basin that responds to storms, as it is simple and requires limited data. In this method it is assumed that intensities of rainfall and infiltration are uniformly distributed in time and space. To apply the rational method, the scientific community suggested that the smallest basin area should be 25 km² (Hua, Liang, & Yu, 2003).

Empirical formula

The empirical formula (Modified dickens formula) has been derived for the first time for Northern India. The formula uses the catchment area as a single parameter affecting the flood peak and other factors are constant based on the specific region. This formula is applicable in the region from which the formula has been developed and then is applied to other areas that at best can give rough estimates (Subramanya, 2006). Even though, northern India and southern part of Nepal have similar catchment, it is not opted to apply the empirical formula for current study because of the data limitation.

Flood frequency analysis

The flood frequency method is the statistical method of flood frequency analysis. The method needs a large-scale data (a minimum of 30 years) to get the accurate result. In case of the data records with less than ten years, flood frequency analysis should not be adopted (Subramanya, 2006).

WECS method

The WECS method (DHM, 1990) is the unique method for Nepal and found to be accurate comparing others. In this method, the whole country is considered as single hydrological region. As per flood records, low flows, long-term flows and high flood flows sub regions are divided. The method is first developed jointly by the Water and Energy Commission Secretariat (WECS) and Department of Hydrology and Meteorology of Nepal in 1982. Later it is modified and came up in improved form in 1990. The World Meteorological Organization (WMO), Water and Energy Resource Development Project (WERDP) and WECS/NEA Institutional Support Programme (WISP) are major partners to develop this method. The following equations are used for flood flow of any river having catchment area ‘A’ below 3000.

$$Q_2 = 1.8767\ (A+1)^{0.8783}$$

$$Q_{100} = 14.63\ (A+1)^{0.7342}$$

Where, the subscript 2 and 100 stand for the return periods in number of years.

The flows for any other return period ‘R’ is then given by:

$$Q_R = exp\,(\ln Q_2 + 3\,\sigma)$$

Therefore, comparing the merits and de-merits of all the methods and their suitability, WECS/DHM method is found to be appropriate for this study. By using this method, the flood discharge for the return period of 2 years and 100 years have been calculated and analysed.

iv. Manning's roughness coefficient (n)

The Manning's roughness coefficient, *n*, is commonly used to represent flow resistance (Phillips & Tadayon, 2006). The friction parameters have been selected from the guidance of the standard hydrological textbook by visual judgment.

v. Computer Applications used for flood modeling

Computer application software such as GIS, HEC GEO-RAS, and HEC RAS has been used to develop the flood plain map in this study.

vi. Geographic Information System (GIS)

GIS is computer based system for mapping and analyzing spatial data. GIS is considered revolutionary new technology, which increases ability to make decision and solve problems. GIS differs from other information system as it integrates common data base operations like query and statistical analysis, unique visualization and geographic analysis benefits offered by maps. This is helpful for explaining events, predicting outcomes and planning strategies. The careful analysis of spatial data using GIS can provide detail information on problem like pollution, deforestation, natural disasters and suggest the way to address them. GIS comprises five components i.e. hardware, software, data, people, and methods (Joerin & Musy, 2000).

vii. HEC-GeoRas

HEC-GeoRas is an extension for ArcGIS. This extension allows users with limited GIS experience to create an HEC-RAS import file containing geometric attribute data from an existing digital terrain model (DTM) and complementary data sets. Water surface profile results may also be processed to visualize inundation depths and boundaries (Ackerman, 2011). HEC-GeoRAS is a set of procedures, tools, and utilities for processing geospatial data in ArcGIS using a graphical user interface (GUI).

viii. HEC-RAS

HEC-RAS is numerical analysis software. It is a computer program that models the hydraulics of water flow through natural rivers and other channels (Prinos, 2008). "It is an integrated package of hydraulic analysis programs, in which the user interacts with the system through the use of a Graphical User Interface (GUI)" (Brunner, 2010). This provides the details of flood profiles. This software is easily available and has precise calibration accuracy (Kute *et al.*, 2014). This is the major part of the modeling where flood simulation is done. This program is one-dimensional, which means the flow is considered to be uniform from point to point upstream to downstream. It includes numerous data entry capabilities, hydraulic analysis components, data storage and management capabilities, and graphing and reporting capabilities (Prinos, 2008). HEC-RAS system is the composition of four one-dimensional river analysis components viz. steady flow water surface profile computations, unsteady flow simulation, movable boundary sediment transport computations, water quality analysis (Brunner, 2010). In HEC-RAS, we can see the two major water surface profile facilities: *a*) Steady flow water surface profile, and *b*) Unsteady flow water surface profile.

ix. Steady Flow water surface profile

This component of modeling system is intended to calculate water surface profiles. The system can handle a single river reach, a dendrite system, or a full network of channels. The component is capable of modeling subcritical, supercritical, and a mixed flow regime water surface profiles. The basic computational procedure is based on the solution of the one-dimensional energy equation. Friction (Manning's equation) and contraction/expansion (coefficient multiplied by the change in velocity head) are used for the evaluation of Energy loss while momentum equation is applied in situations where the water surface profile is rapidly varied. These situations include mixed flow regime calculations i.e., hydraulic jumps, hydraulics of bridges, and evaluating profiles at river confluences (stream junctions). The steady flow system is designed for application in flood plain management and flood insurance studies to evaluate floodway encroachments (Brunner, 2010).

x. Unsteady Flow water surface profile

This component is capable of simulating one-dimensional unsteady flow through full network of open channels. This component gives the design value for subcritical flow regime. However, new releases of the model give the mixed flow regime (subcritical, supercritical, hydraulic jumps, and drawdown). Special features of this component include: Dam break analysis; levee breaching and overtopping; Pumping stations; navigation dam operations; pressurized pipe systems, and sediment analysis (Brunner, 2010).

Upon discussion with TSLUMD authorities, it was found that that the study should also aim to evaluate land use plan from disaster (flood) management perspective for which requires the evaluation of flood way encroachment. From the experience knowledge, it is concluded that, steady flow analysis is designed to evaluate flood way encroachment. Therefore, in this study, steady flow analysis has been used for the flood simulation as required for the project. It has to keep noticed that; due to the lack of unsteady flow data, this study is limited to choose steady flow analysis.

3.1.3 Methods

In order to obtain the objectives defined in TOR regarding flood risk, spatial and non-spatial data were collected. Both qualitative and quantitative approaches were adopted for data generation. The primary sets of data were acquired using the method of interview with the people of residing in the flood prone areas and government officials. The secondary data were collected from the National Land Use Project. The census of 2011 was obtained from website of CBS of Nepal (www.cbs.gov.np). A short description of data collection and processing is given in the following sub-sections.

i. Data Collection

Data collection is the systematic gathering of information necessary is this study. The information can be of people, objects or phenomena. Haphazard collection of data may create difficulty in answering the set question in a conclusive way (Chaleunvong, 2013). So, the method applied for collecting data is both qualitative and quantitative, which are such as available information, observation, interviewing face to face, written questionnaire, etc. The primary data was obtained using the method of interview with the people residing in flood prone area to get responses to the frequency of occurrence of flood and the methods they adopted to cope with. In addition, more information was collected through the questionnaire being administered to the local people. Non-probability, purposive sampling was used with the sample size of twelve questions.

ii. Data Analysis

- ***Conversation with local people***

From the information obtained through interview with local people, it is known that flood was not frequent in most of the project area (Gaunpalika/Nagarpalika). The package 03 cover five Nagarpalikas and Six Gaunpalika:- which are: Bagung Nagarpalika, Jaimini Nagarpalika, Kushma Nagarpalika, Phalewas Nagarpalika, Galkot Nagarpalika, Bihadi Gaunpalika, Modi Gaunpalika, Bareng Gaunpalika, Jaljala Gaunpalika, Mahashila Gaunpalika, and Paiyun Gaunpalika. However, there were some major floods: 2044, 2061, 2068 and 2072 BS in Kaligandaki Nadi (river bank areas of Jaimini Nagarpalika, Phalebas Nagarpalika, Jaljala Gaupalika & Baglung Nagarpalika), Modi khola (river banks of Modi Gaunpalika and Kushma Nagarpalika). Similarly, in those years, Hugli River also shown its danger condition and few peoples were also washed out. The other places are significantly affected but not recorded well. The main problems due to flooding are: River bank cutting, loosing of agricultural lands, frequent landslides etc. As per them, many agricultural lands have been converted to river bank due to bank cutting, which was verified during the time of field visits.

- ***Analysis of Watershed area***

While analyzing flood hazard and risk areas for Package 3 project Gaunpalikas / Nagarpalikas (Four Nagarpalikas: Baglung Nagarpalika, Jaimini Nagarpalika, Kushma Nagarpalika, Phalewas Nagarpalika, Galkot Nagarpalika, Bihadi Gaunpalika, Modi Gaunpalika, Bareng Gaunpalika, Jaljala Gaunpalika, Mahashila Gaunpalika, and Paiyun Gaunpalika.), following rivers were digitized from the view II image. The names major rivers are: Modi Khola, Rati Khola, Kaligandaki Nadi, Thuele River, Lahami River, Dharam River, Gaudi River, Saune River, Bhim River, Seti River, Hugdi, Khola, Palung Khola, and Tam Khola. Then, digital elevation model was prepared by using contour and station point from the topographic maps published by the Survey Department of Nepal. Water discharge for return period 100 years was calculated with the determination of watershed area for flow direction and flow accumulation. The process adopted in this study is shown in the Figure 3.2.

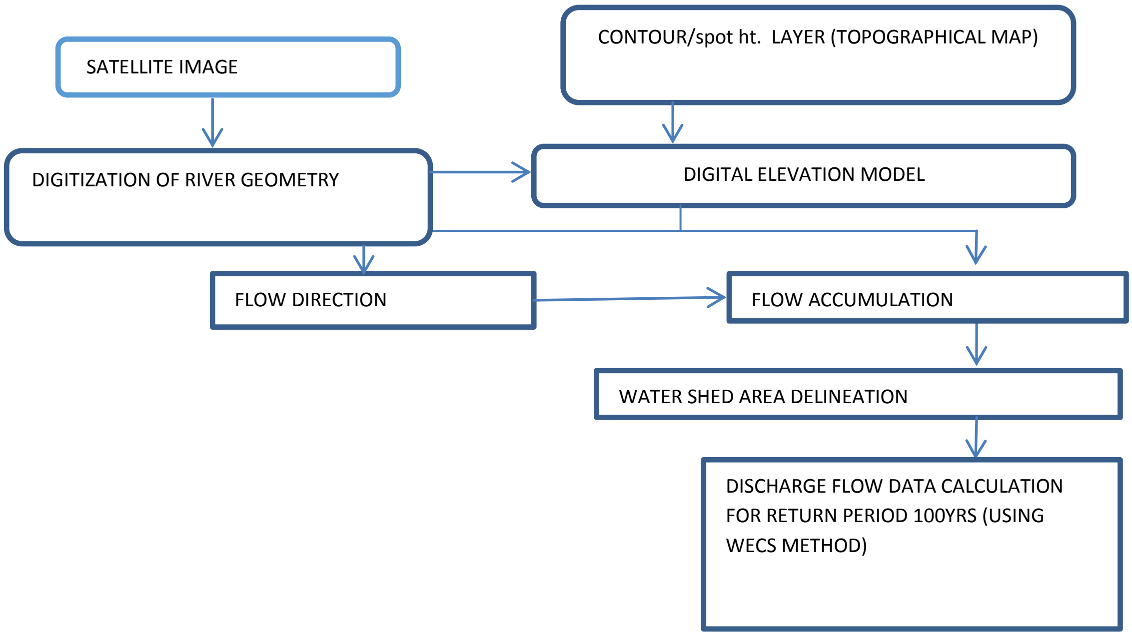

Figure 3.2: DEM processing and Discharge calculation

Calculated flow discharge for the given catchment area of return period 100 years is given in Table 3.1.

Table 3.1: Discharge calculation for given Return Periods (Package 3)

River	Chainage Km+m	Catchment Area (A) Km2	Discharge, m3/s	River	Chainage Km+m	Catchment Area (A) Km2	Discharge, m3/s
Modi	35+209	1.30	27.00	Dharam	17+507	201.09	721.07
Modi	18+970	481.95	1366.99	Dharam	61	336.79	1051.42
Modi	12+524	546.42	1498.71	Gaudi	8+003	12.46	98.67
Modi	6+395	632.03	1667.43	Gaudi	3+099	43.68	238.09
Modi	46	668.86	1738.12	Gaudi	45	47.82	254.11
Rati	14+949	4.15	48.74	Saune	15+368	9.41	81.71
Rati	7+693	24.35	157.06	Saune	8+277	41.49	229.47
Rati	31	66.36	321.85	Saune	151	61.45	304.45
kaligandaki	64+436	4570.89	7120.11	Bhim	9+758	4.30	49.79
kaligandaki	60+526	4956.46	7556.20	Bhim	4+222	20.45	138.92
kaligandaki	56+466	6060.04	8757.71	Bhim	77	29.35	179.23
kaligandaki	43+465	6275.65	8985.38	Seti	21+196	3.09	41.18
kaligandaki	33+554	6987.70	9722.99	Seti	15+194	34.91	202.83
kaligandaki	24+758	7153.43	9891.76	Seti	9+046	79.94	368.31
kaligandaki	13+246	7248.66	9988.26	Seti	5+068	106.39	453.30
kaligandaki	10+368	7303.79	10043.97	Seti	59	137.92	547.61
kaligandaki	27	7502.84	10244.19	Hugdi	14+762	10.01	85.13
theule	17+095	3.78	46.13	Hugdi	4+927	39.53	221.67
theule	3+431	75.66	353.90	Hugdi	14	71.26	338.89
theule	73	75.66	353.90	Palung	11+909	5.64	58.74
lamahe	11+999	3.36	43.10	Palung	9+771	13.32	103.24
lamahe	7+066	22.00	146.22	Palung	64	35.55	205.46
lamahe	62	48.81	257.89	Tam	9+244	3.74	45.85
Dharam	24+225	126.86	515.25	Tam	23	20.59	139.57

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iii. Pre-Processing in GIS environment

RAS layers (Stream centerline, river banks, flow path centerlines and cross sections) were created which was later followed by layer setup and finally RAS-GIS import file was created. The file then processed by the HEC-GeoRAS layer.

iv. HEC-RAS Processing

The file created in HEC-Geo RAS was imported in Geometric Data Editor interface in HEC-RAS. The study flow analysis was preceded by using the flood discharge for return periodic 100 years, which was obtained from WECS/DHM method. Reach boundary conditions were defined as critical depth for both upstream and downstream. Manning's constant for left and right bank was set as 0.04 while 0.035 for centre of channel. It was judged by field observation. Mixed flow analysis is done. Then the generated data is exported in GIS format. The process in block diagram form is shown in Figures 3.3.

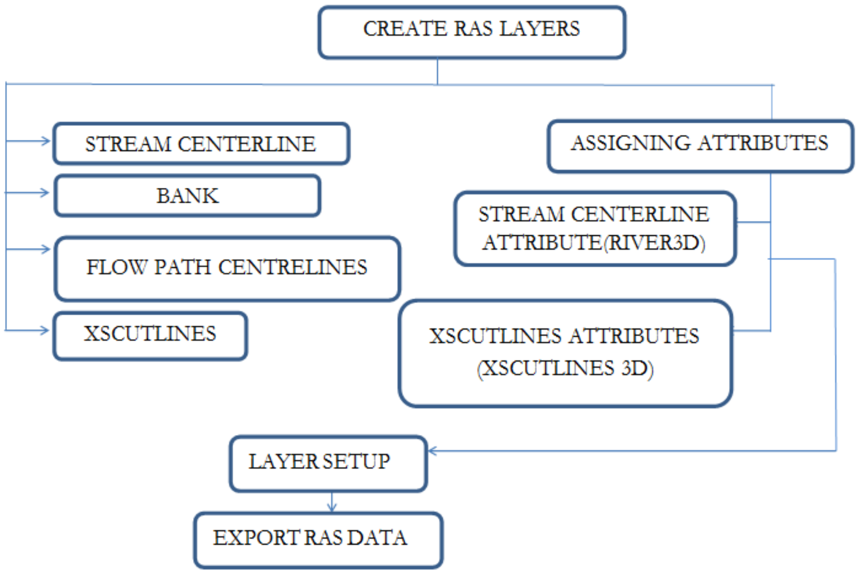


Figure 3.3: HEC-GeoRAS processing

Each of the rivers has its own water surface profiles and they are different in nature. For example, Kaligandaki Nadi water surface profile is shown in Figure 3.4.

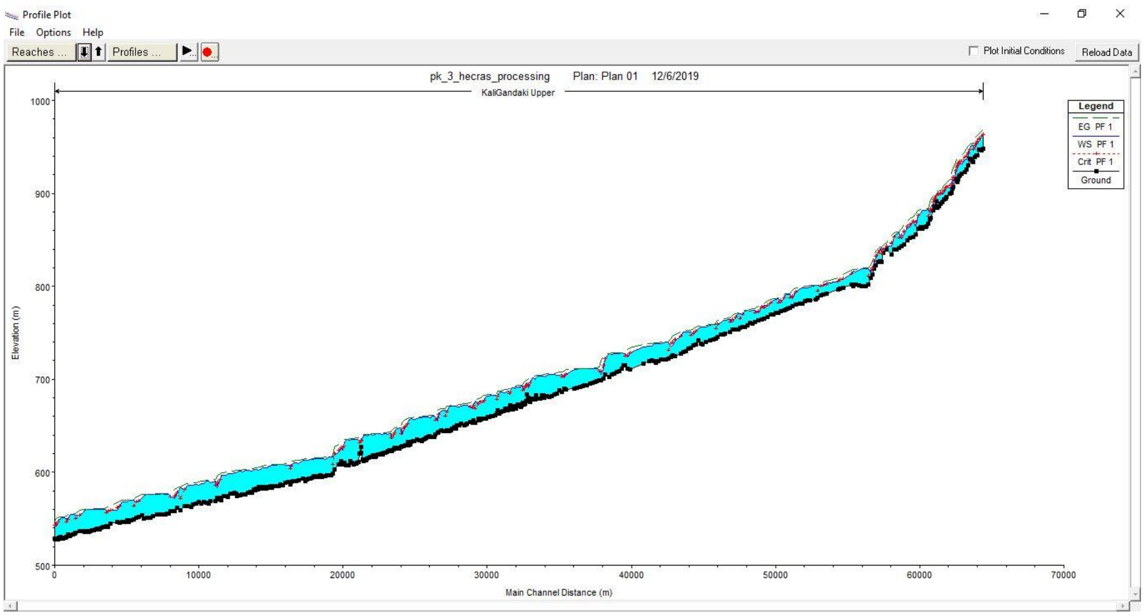


Fig 3.4 Water Surface Profile of Kali Gandaki for 100 years floods

v. HEC GEO RAS Post Processing

In this phase inundation mapping was performed with the generation of water surface which was later followed by flood plain delineation. The process involved is given in Figure 3.5.

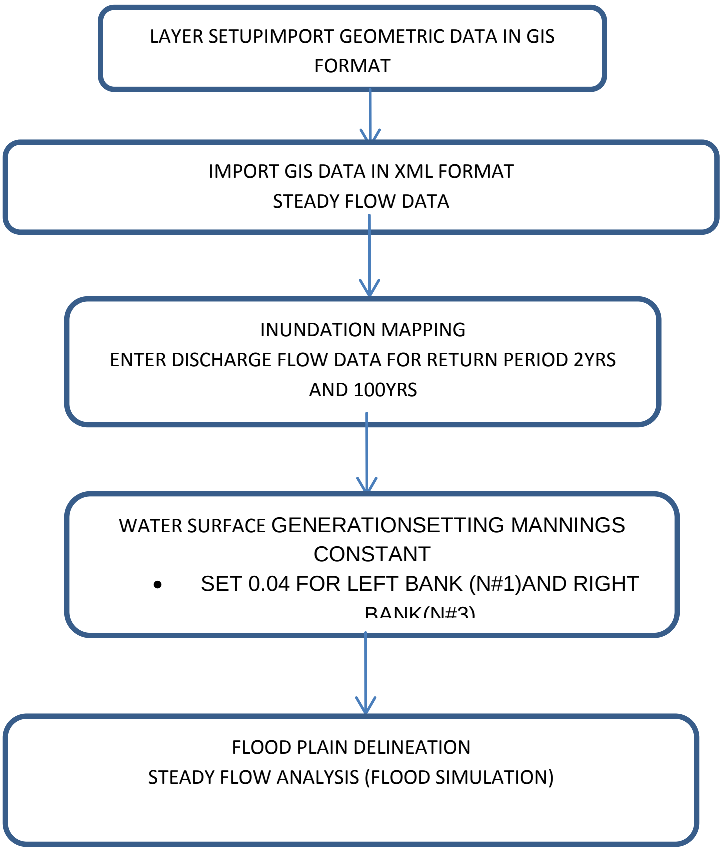


Figure 3.5: HEC-GEO RAS post processing

3.1.4 Result

Flood hazard map was prepared by overlaying land use map with flood area polygon for return period of 100 years. This has given clear picture of possible flood that can affect land use of the area. The assessment has been done for period which is represented in given map shown at the end of this section.

Preparing flood Hazard Map

In package 03 project gaunpalikass, Maor Rivers are: Modi Khola, Rati Khola, Kaligandaki Nadi, Thuele River, Lahami River, Dharam River, Gaudi River, Saune River, Bhim River, Seti River, Hugdi, Khola, Palung Khola, and Tam Khola. which are considered for processing job. The major problems due to floods are bank cutting and land slide of the bank areas.

Flood hazard map was prepared by overlaying land use map with flood area polygon for return period 100 years. This has given clear picture of possible flood inundation that can affect land use in all Gaunpalikas under package 03, which is presented in Table 3.2. As per processed result, flood hazard map is presented in Figure 3.6 for these Gaunpalikas as well as Nagrpalikas.

Table 3.2 100 –year Return Period Flood Prone Area in Bareng Gaunpalika

Bareng Gaunpalika				
Land use Type	**High**	**Medium**	**Low**	**Grand Total**
Agricultural	24.90	16.67	144.27	185.84
Commercial	0.02	0.00	0.00	0.03
Cultural	0.00	0.00	0.13	0.13
Forest	24.85	4.28	122.64	151.77

Industrial	0.00	0.00	0.01	0.01
Others	0.75	0.64	2.91	4.30
Public	0.32	0.36	3.43	4.11
Residential	0.16	0.42	2.34	2.92
Total	51.00	22.36	275.74	349.11

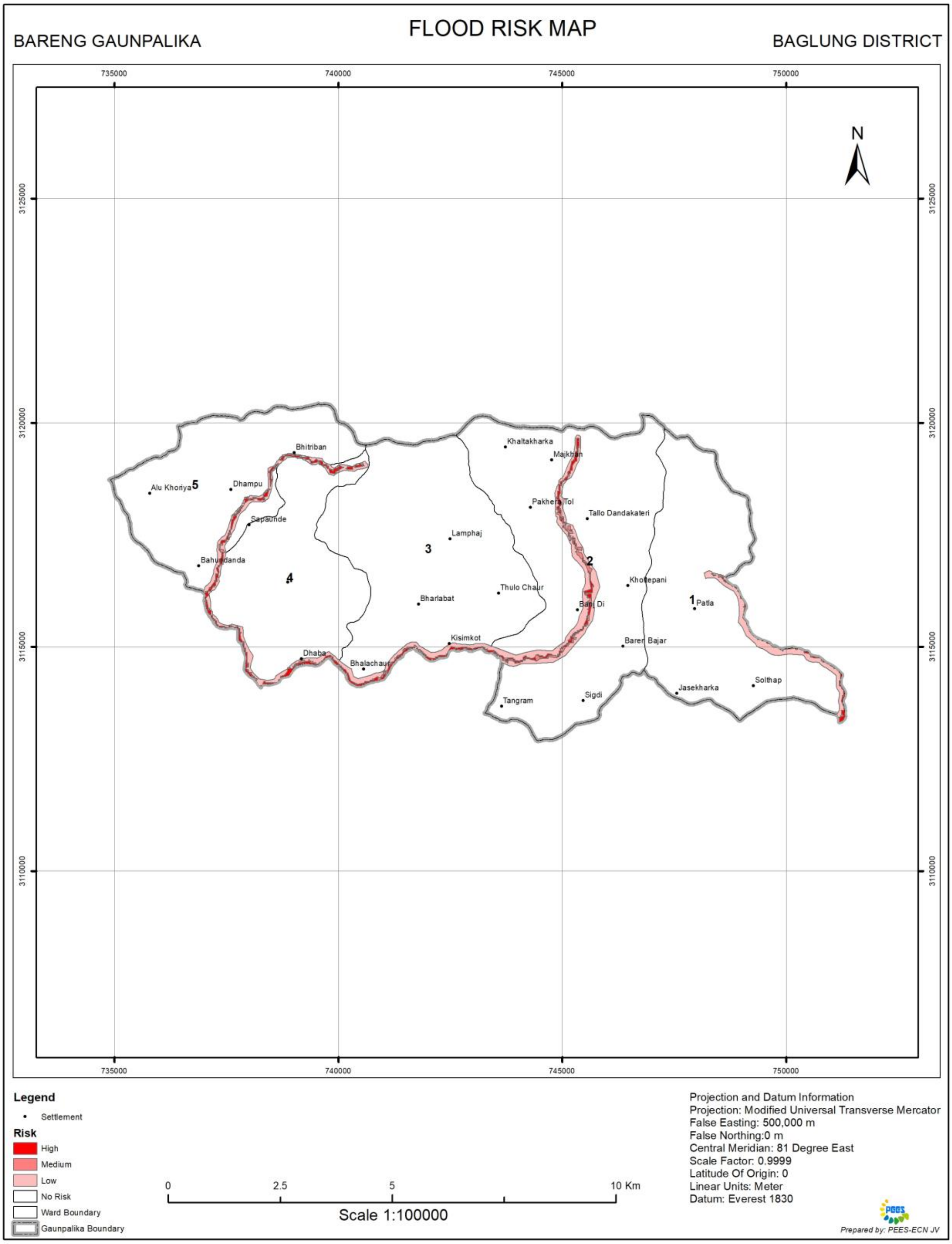


Figure 3.6 : Flood Risk of Bareng Gaunpalika

Flood depth for 100 year return period

From experience, it shows that there is possibility of occurrence of flood, affecting the nearby areas of the river and streams, because of bank cutting and land sliding. This may destroy the agricultural land. It is necessary to make conservation of agricultural land from entering the floods. In addition at present the people of the nearby areas of the rivers are found suffering from water logging problem during the summer rainfall season. From observations it seems Modi River, Kaligandaki Nadi, Seti Nadi and Hugdi Rivers are the most flood prone river in the package 03.

According to flood assessment for return period 100 years, It is found that the 76.47% flood depth is less than 0.5 m while 19.64% of flood is in between the depth of 0.5 m -1.5 m while 3.89 % has the depth greater than 1.5 m which is illustrated statistically in figure. The graphical representation for the return period 100 years in the given in Figure 3.7.

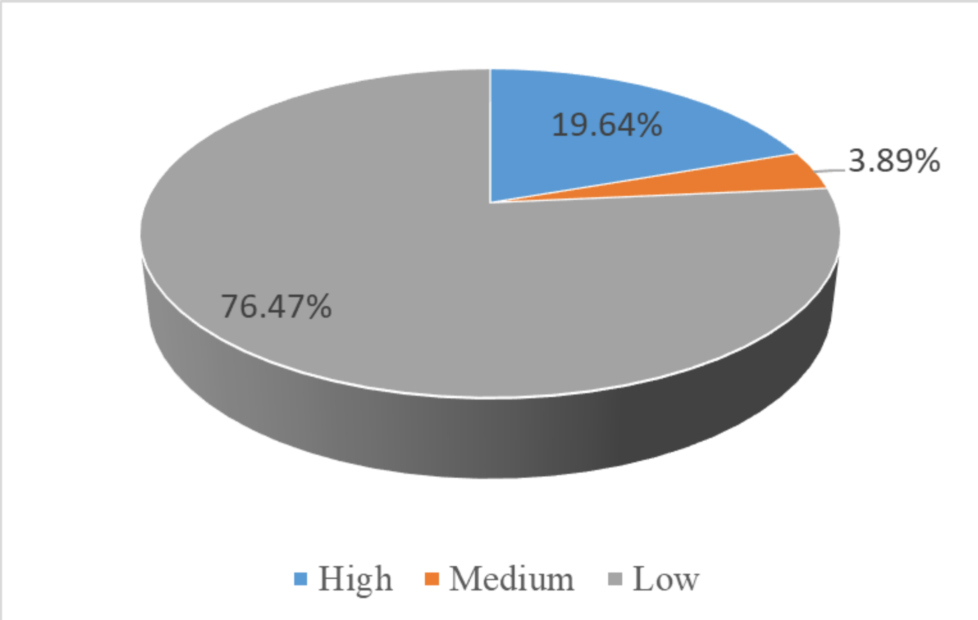


Figure 3.7: Flood Depth coverage (Ha) for return period 100 years

3.1.5 Discussion

It is found that the settlements near by the high flood risk areas as shown in Figure 3.6 are more prone to flood. The people in such area are at risk of flood hazard so these people need to be shifted from such flood risk area to the area free of flood. It is also suggested to take immediate action against mitigating flood hazard by undertaking river training or embankment or levee construction along the rivers having flood potential.

Major flood had occurred in 2044, 2042, 2061, 2068 and 2072 BS in Modi River, Kaligandaki Nadi, Seti Nadi and Hugdi Rivers and servely affected in the river bank areas. Few cattle and 2-3 human lives also lost in those floods. However, these rivers have minor flood problem. The probability of entering floods of these rivers usually is in the months of June, July, August and September. From interview with the local peoples, it is noticed that many agricultural lands have been converted to river bank due to bank cutting. According to the local people, flooding can be minimized with the construction of embankment dams along the rivers.

3.2 Fire Risk

Land Use and Fire Hazard

The overall impact of land use change on drivers of fire risk is often specific to the location, ecosystem, land use system, and underlying climate of a particular place, and thus it can be difficult to generalize across multiple systems, although some general trends have emerged. Fire risk can drive land use change by creating the need for alternative vegetation management activities, such as type converting flammable fuels and landscape planning. Land use change can in turn impact fire risk by impacting fuel loads and ignitions. Combined, these impacts interact on the landscape and thus inform both future land use change decisions and future fire risk (Figure3.8). Low density housing can lead to increased fuel loads if houses are not designed with flame resistant materials. But if plant vegetation or natural ecosystem near their homes, there is low chance of firing. Alternatively, small scale fuel treatments associated with increased housing density can decrease fuel loads, although different ownership types may be more or less likely to manage fuels. Increased land use intensity can result in decreased fuel loads, as is the case in dense cities where most buildings are built from non-flammable concrete and steel (Van Butsic, Maggi Kelly and Max A. Moritz; 2015).

Each year Nepal experiences fire hazard in different areas of the country. The fire hazards take place in both built-up areas as well as forests. Fire hazards can take place in many places, however, so far as the ecological regions are concerned the Terai belts experienced it more and vulnerable as well. In the hilly regions, particularly during the dry, stormy season between April and June when temperatures are higher, wooden houses in clustered settlements are vulnerable to fire risk.   This fires cause great loss of life and property and can have a devastating impact on local economies. Likewise, the forest fire occurs every year in Nepal, particularly in the forests of Terai and Churia hills.

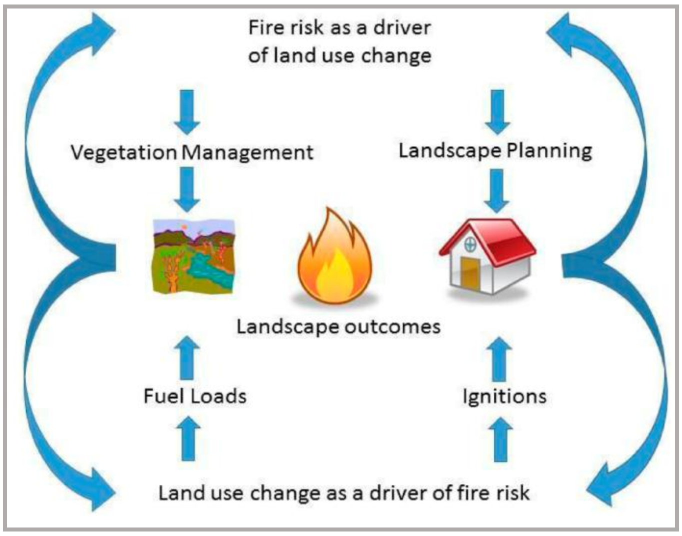


Figure 3.8 Conceptual model of interactions between land use changes and fire risk (Source: Van Butsic, Maggi Kelly and Max A. Moritz (2015). Land Use and Wildfire: A Review of Local Interactions and Teleconnections; Department of Environmental Science, Policy and Management. University of California Berkeley, Berkeley, CA 94720, USA).

3.2.1 Data

It is common that forest fire occurs every year in Nepal, particularly in the forests of Terai and Churia hills. Government of Nepal has given less priority in managing forest fire due to limited resources. Nepal has adopted various forest management approaches including community forestry, leasehold forestry, protected forestry and government managed forestry. All categories of forests and bamboo plantation are affected by fire albeit the magnitude varies. Forest fire is considered as a problem in forest management systems in Nepal since we have not been able to use it as a management tool. The Fire Management is an important initiation to safeguard forest and other resources by reducing fire damages through mobilizing government, non-government, private sector, civil society and local people.

It is common in Terai during the dry, stormy season between April and June when temperatures exceed 35°C, houses in the region are wooden and have thatched roofs, they are extremely vulnerable to incendiary lighting strikes, suffers from numerous fire outbreaks mainly during the process of cooking. In the winter, the major cause of fires is the short circuiting of electrical appliances, particularly heaters. In urban and other areas, houses are built in close proximity; these too are vulnerable, as fires easily leap from one house to the next. Due to electrical appliances industries area also in high risk of firing. This fires cause great loss of life and property and can have a devastating impact on local economies.

Cause of Firing

1. Very few fires are naturally caused in Nepal (NBS, 2002). Karkee (1991) observed that 40% of forest fires in the mid-hills are caused by accidents while 60% are started deliberately e.g. Shifting cultivation, forest encroachment.
2. Cattle grazing for new grass and smokers known causes of forest fires.
3. Although it is not common, local communities identified bamboo as a fire igniter. Friction exerted between bamboo culms within the clumps sometimes produce fire.
4. In settlement areas, due to negligence while cooking, firing is common house and shelter.
5. Fault wiring and electrical equipments, candles, home heating and cooking, children activities, Flammable liquids (fuels, solvents, adhesives, paints, and other raw materials – can ignite or explode if stored improperly) and careless smoking were the main sources of firing in houses and settlements areas.
6. Industrial and chemical fires: These fires occur when hazardous materials such as petrochemicals spill or leak and subsequently explode, technology fails, vehicles collide, and factories catch on fire. Within minutes, an entire industrial area can be aflame and billion of rupees of property swallowed up. They also take lives and destroy the environment.

The identification of fire risk areas is a difficult process. However, attempts can be made to identify the risk areas based on the past occurrences (hot spots), buffer analysis in ArcGIS, a survey of building materials and observation of building density, and socioeconomic status of the residents, etc. The present analysis has tried to evaluate the fire risk areas by collecting data through buffer analysis in ArcGIS, consultation with local communities as well as field observation.

3.2.2. General Approach and Methodology Frameworks

a. General Approach: The general approach for the fire risk layer data collection are as follows:

i. For Forest:

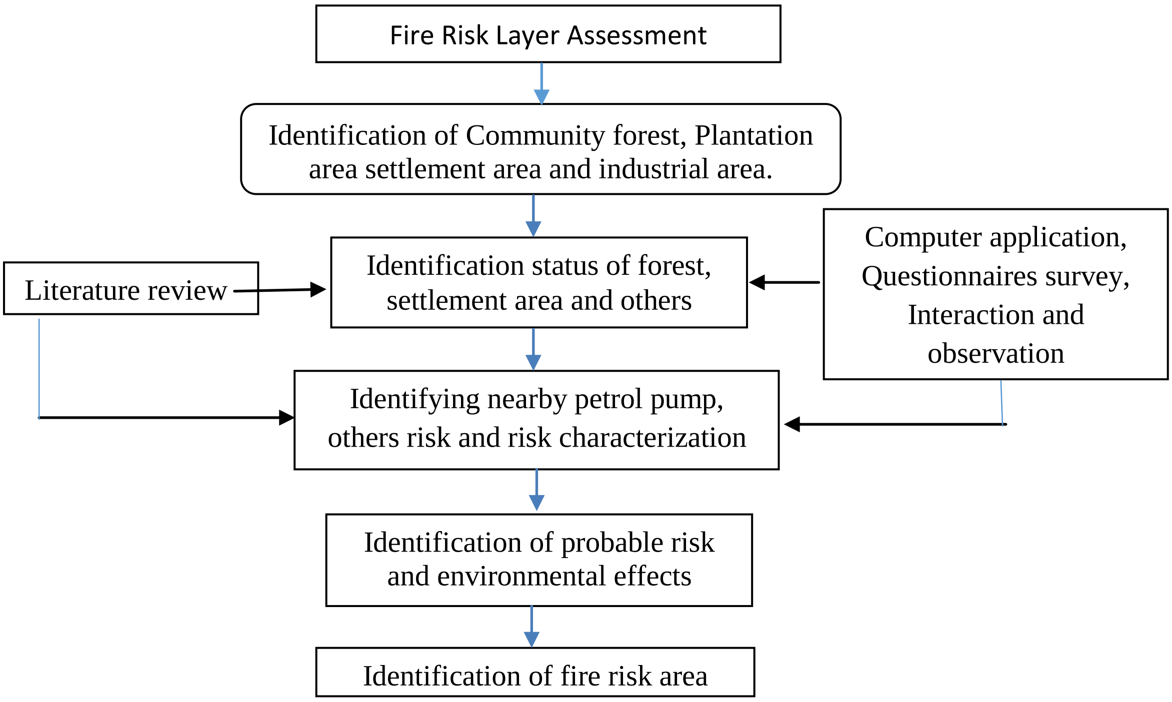
- Identification of community forest or other plantation.
- Identification of types of forests other plantation and present management status.

- Identifying nearby settlement areas and foot trail or road along or inside the community forest other plantation.
- Identification of risk, and its characterization with environmental effects.
- Identification of extend of fire risk area.

ii. For settlement areas and petro-chemical station.

- Identification of settlement areas and others.
- Identification of types of settlement with present status.
- Identifying nearby industries, petro-chemical station and forest.
- Identification of probable risk, its characterization with probable environmental effects.
- Identification of extend of fire risk area.

b. Methodology Frameworks:



3.2.3. Methods:

The following methods were adopted for the collection:

- *Literature Review*

The relevant information was collected from various books, publications, journal etc to access the fire risk. Similarly different types of maps such as topographical map, images were also studied. Required relevant information has been drawn from different internet WebPages.

- *Field Investigation*

A detailed field investigation was carried out for the data collection. Each VDC was visited during the field visit. The data regarding to community forest, settlement status, industries and Petro-chemical station was taken. Along with this, the probable environmental impact created by past firing was collected.

- Questionnaires Survey and Interaction approach:

The data were collected through the extensive consultation with government representatives at various levels, experts and professionals, local communities and industrial stockholders. Additionally, interactive methods were adopted to collect the data among local government representatives, community forestry user groups and local communities to find out the impact status and extend of impact.

- Computer Application

In order to identify fire risk of any area, the visible Infrared Imaging Radiometer Suite (VIIRS) having 375 m spatial resolution active fire product, petrol pump station and transmission line location was used and analyzed.

The VIIRS fire product is the latest product to be added to FIRMS. It provides data from the VIIRS sensor aboard the joint NASA/NOAA Suomi National Polar-orbiting Partnership (Suomi NPP) satellite. The 375 m data complements Moderate Resolution Imaging Spectroradiometer (MODIS) fire detection; they both show good agreement in hotspot detection and risk zone identification but the improved spatial resolution of the 375 m data provides a greater response over fires of relatively small areas and provides improved mapping of large fire perimeters. Consequently, these data are well suited for use in support of fire management (e.g., near real-time alert systems), as well as other science applications requiring improved fire mapping fidelity.

For risk layer assessment, parameters like fire occurrence location, petrol pump station, and transmission line feature were buffered on the basis of their potential to fire. Sometimes regarding to fire pattern, surrounding environment, technology, human factors, infrastructures, the buffering zones might be change. Normally, on this note for forest fire incident points data of VIIRS buffering, 200m is high risk, 200-500m is moderate, 500-1000m is low risk and more than 1000m is considered as no risk zone class. Likewise for petrol pump buffering, 500m distance from petrol pump is high risk, 500-1000m is moderate risk, 1000-1500m is low risk and more than 1500m is as no fire risk class. Similarly for high tension transmission line, buffering is difference on the basis of their power supplied i.e. for 33KW; 6m distance is high risk and otherwise no risk, for 132KW; 9m distance is high risk and 220KW; 30m distance is high risk. For Industry, 200m buffer is considered as high risk for fire. All these buffering distances are based on expert consultation.

3.2.4. Result

This area has been experiencing irregular wildfire events in recent years during the dry season from November to June every year and it is increasing each year. The map shows that number, forest fire is usual at forest area and settlement area in limited area. Most of the forest is being managed by community, so, forest fire is comparatively low in this Gaunpalika. In, forest and settlement, fire is occasional in this Gaunpalika. From the data and map, it can be concluded that very low area is in the risk of fire. Once forest fire starts, it was very difficult to take under control. Some of the incident of fire are as follows:

Table 3.3: fire incident table

S.No.	Location	Ward No.	Incident Date	Estimated Loss
1	Bareng Gaunpalika	3	08-02-18	1000000

The settlements of this study area in scattered and clumped almost in all wards of the Gaunpalika. The incident of settlement fire is low in this Gaunpalika. The fire on forest and settlement area will cause huge economic and human losses. The below table 3.4 and figure 3.9 shows the area and location of the fire risk area.

Table 3.4: Area under fire risk

S.N	Fire_Risk	Area'Ha'	Remarks
1	No Risk	5685.193	Managed forest and settlement area
2	High	190.4455	Because of unmanaged forest and settlement area
3	Moderate	516.9151	Because of moderately forest and settlement area
4	Low	1135.835	Because of satisfactory managed forest and settlement area

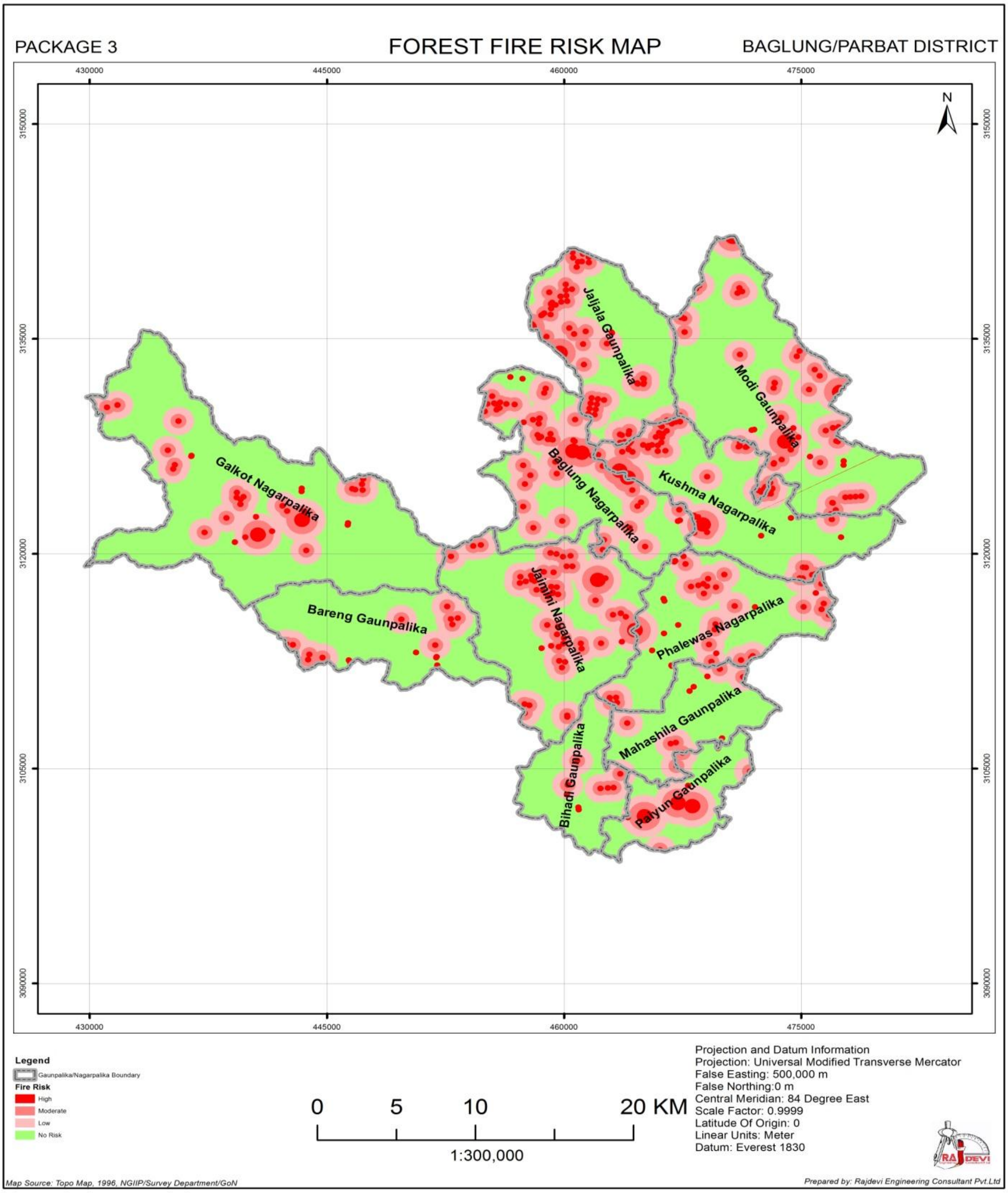


Figure 3.9: Fire risk area under package 03 (Parbat and Baglung)

3.2.5. Discussion

The incident of fire based on area in this Gaunpalika is low. Based on fire risk, low area falls under fire risk. The incident of fire was seen in low area at North West and South east part. It was very difficult to douse the forest fire because of drought and rising temperature. Since the people of this area are middle class and poor, the incident of forest fire is common in all area because they directly depends on forest resource to sustain their lives. Local farmers traditionally use fire as a tool for burning agricultural residues-straws, stalks, husks etc to prepare their farms for next crop cultivation. Similarly, settlement areas with cluster pattern, located nearby forest area, human negligence, house style more will be chance for fire. The number of incident of fire in this region is because of such house pattern, human negligence and activity, unmanaged forest etc. More safe area means, forest area and settlement area are managed.

Finally, to low the risk of firing it should be ensure the meaningful participation of local communities in fire management. Along with this, various motivational, technical and financial sources along with institutional and policy commitments are necessary.

3.3 Land Slide and Soil Erosion Risk

Landslides are a form of erosion and are an important process in the shaping and reshaping landscapes and landforms. Landslides re-distribute soil and sediments in a process which can be extremely rapid or very slow. Landslide hazard, defined as the annual probability of occurrence of a potentially destructive landslide event. Landslide hazard is frequent phenomenon is Nepal due to several reasons including tectonic activities, uncontrolled and unsafe development, heavy precipitation and environmental degradation. However it is observed that rainfall induced landslides is most prevalent in the hills and mountainous districts. In view of rapid development in hills and mountains in the country, it has become imperative to review, identify and analyze landslide prone areas and their causative factors. In Nepal, high susceptibility zone of landslide are identified in the areas of high intensity rainfall and earthquake hazard. Earthquake induced hazard are distributed in centre (hill) zone of Nepal, which is largely dependent on Pick Ground Acceleration (PGA) values.

Landslide and soil erosion susceptibility refers to the classification, area spatial distribution of potential landslide and soil erosion occurrence area. Landslide and soil erosion susceptibility zoning refers to the division of land into homogeneous area or domain and their ranking according to degree of potential landslide and soil erosion susceptibility, hazard or risk. Landslide inventory, susceptibility and hazard zoning for local areas for preliminary level risk zoning and the advance stages of planning for larger engineering structures are carried out at 5000 to 2500 scale covering are from 10 to 1000 square km (Fell et. al., 2005).

3.3.1 Data

Landslides and soil erosion are the result of triggering natural factors mainly extreme precipitation, rainfall intensity and seismicity and susceptibility factors dominantly, slope, lithology, soil moisture and land cover and land use. Peak of monsoon usually correlate with high landslide and soil erosion events in Nepal due to high precipitation. Data on the importance of earthquake triggered vs. precipitation triggered in terms of fatalities may not be easily available. However, it is known that in some cases, a significant share of the earthquake fatalities are killed by earthquake triggered landslides. All relevant spatial data at available geographical coverage and format are collected, compiled and processed in GIS platform for the analysis purpose.

Data collected for land use resource mapping and topographical, soil and geology data are used for landslide susceptibility analysis. Data and source of data are detailed below:

- Land cover land use (present land use, Satellite image 2018),
- Slope and Slope Aspect(from DEM, Satellite image 2018)
- Relative Relief (derived from DEM)

- River network: Drainage density (Present land use, Satellite image 2018 & Topographical sheets, 1995-97)
- Geology: Fault and lineament, Lithology and Rock type (DoMG, 2009),
- Soil (Land system, SOTER 2009), and
- Rainfall/ precipitation trend (DHM, 2009-2018).

3.3.2 General Approach and Methodology Framework

Landslide susceptibility assessment are based on different methods. Some common landslide susceptibility mapping methods are: Geomorphologic mapping, Inventories, Statistical modeling, index based Heuristic analysis and Process based mapping and analysis. The current landslide susceptibility is based on process based mapping. The overall methodology applied is presented in Figure 3.10 and the approach followed for landslide mapping includes:

- Inventory of existing landslides from satellite image
- Verification of landslides in the field
- Mapping landslide susceptibility based on susceptibility factors integrating scientific methodology and field landslide data characteristics.

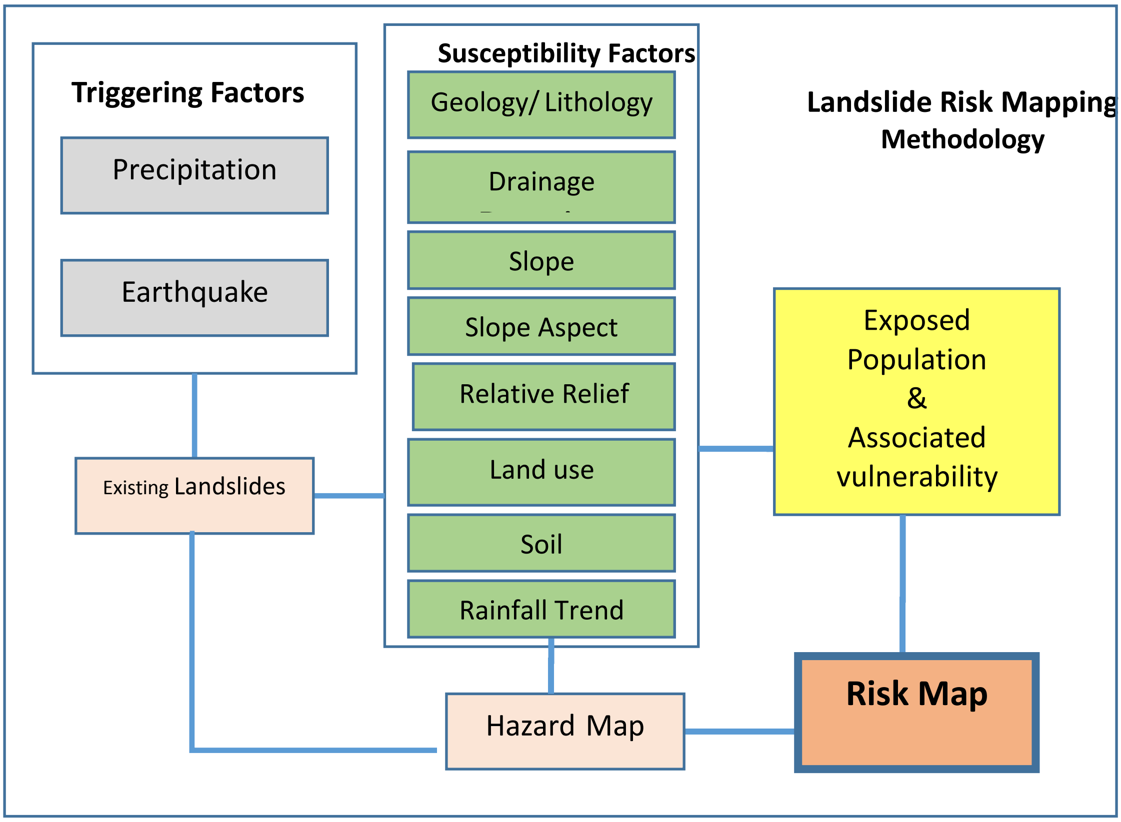


Figure 3.10: Landslide Risk Mapping Methodology

Erosion susceptibility is the major soil factor limitation that affect soils and agriculture production. Some common approaches used for soil erosion susceptibility assessment are: relative probability of occurrence of soil erosion based past events, relative probability of occurrence based on set of causative factors. In the area where erosion events are not recorded and studied, assessment based on causative factors becomes imperative. With the technological advancement, soil erosion assessment based on remote sensing, GIS and statistical techniques are becoming universal (Abdulkadir, et. al., 2019).

Climate particularly the rainfall intensity, soil, topography, and land use are the four major factors which determine rates of soil erosion in an area. Though erosion is directly related to the forces applied to the soil by erosive agents, field conditions at the site and management practices also play a major role. In general, soil high in silt content, low in clay and low in organic matter content are most erodible. Stable soil structures infiltrates water easily, which reduces overland water flow and hence, top soil flow Organic matter contributes in binding soil particles in order to form stable structure. The direction, shape and length of slope triggers water runoff and rate to infiltrate which increases soil erodibility. The greater the slope length, the greater the soil erodibility. GIS based multi-criteria analysis (MCA) method is adopted for the current assessment. The data layers used and methodology adopted is shown in Figure 3.11.

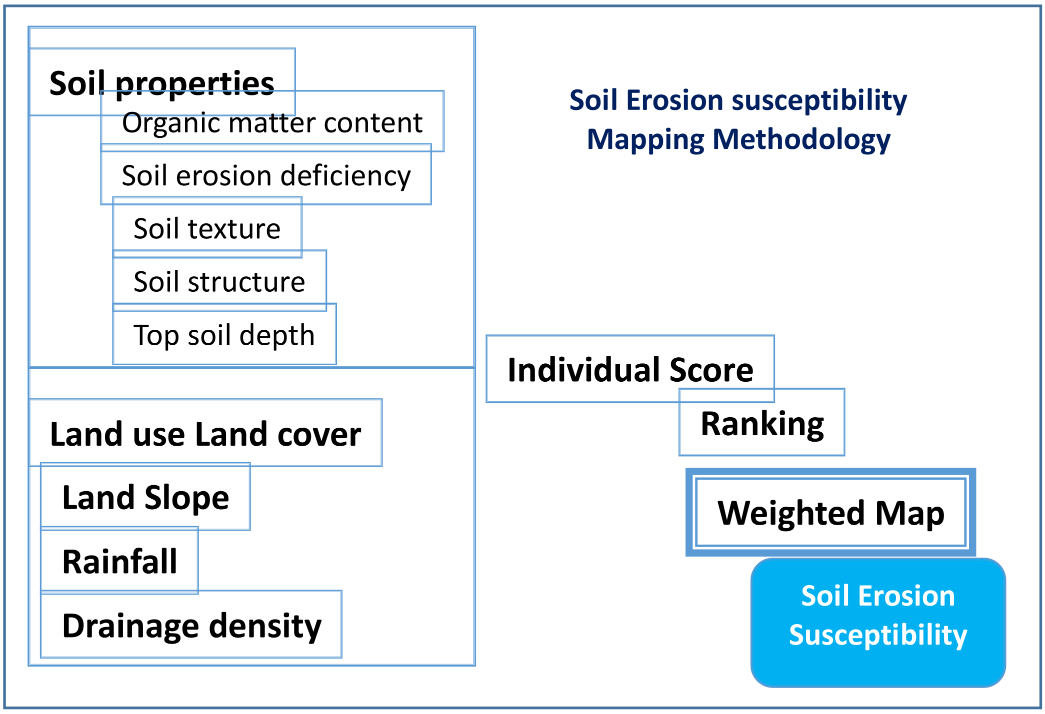


Figure 3.11: Soil Erosion Figureping Methodology

3.3.3 Methods

Landslide susceptibility zoning with existing landslide data integration provides quantitative measure on landslide distribution with the assumption of continuous landslide density in space. Landslide susceptibility zoning usually involves developing an inventory of landslides which have occurred in the past together with an assessment of the areas with a potential to experience land sliding in the future, but with no assessment of the frequency (annual probability) of the occurrence of landslides (AGS, 2007).

Landslide and soil erosion susceptibility zoning is carried out in a GIS-based system with multi criteria analysis, MCA using number of spatial data layers so that the zoning can be readily be applied for land use planning and can be up-dated as more information becomes available. Standard processing and conversion methods are adopted in this analysis to minimize data error and methodology is devised accordingly. Landslide susceptibility mapping was carried out based on Nepal hazard assessment methodology(MoHA, 2011) and weights are assigned as specified in landslide hazard zonation mapping in mountainous terrain guideline (Bureau of Indian standards, 1998) combining triggering factors (mainly extreme precipitation and seismicity) and susceptibility factors (slope, lithology, and soil moisture). The Equation 1 formula was used for weighted spatial analysis using MCA:

Landslide Susceptibility Ranking (LSR): $\mathbf{LSR} = \Sigma\ (Pc_{rn} + Eq_{rn}) + (Ge_{rn} + Dd_{rn} + Lu_{rn} + Slp_{rn} + So_{rn} + RR_{rn} + SA_{rn})$…….....(**Equation 1)**

where, rn = Rank,

Factors: *Pc*= Precipitation, Eq = Fault and Lineaments, Ge = Geology, Dd = Drainage density, Lu = Land use/Land cover, *Slp*=Slope, So = Soil texture *RR*=Relative Relief,SA=Slope Aspect)

Based on landslide inventory, geology, topography and geomorphology, soil and land cover/ land use, and using equation 1, weighted value are calculated. Rank 1 to 3 are assigned for each susceptibility factor and high to low susceptibility rank were summed and final rank grouped as **High, Moderate** and **Low** through Jenk's natural break method. Higher the rank (i.e. value 1) higher the landslide susceptibility (High) and vice-versa.

3.3.4 Result

The landslide mapping of Package 3 is carried out using susceptibility methodology outlined under methodology chapter by using overlay analysis in GIS environment. Because the forest coverage in the project area is high with more than 57 percent area under forest, landslide susceptibility is relatively moderate covering 27.4 percent of the total area. Table 3.5 details the area under different landslide susceptibility zones and Figure 3.12 shows the distribution of landslide susceptible area in the project area. Out of the total susceptible area, around 16 percent area is under high susceptibility zone covering more than 328 hectare. While 64.7 percent area has medium susceptibility of landslide occurrence. The south-eastern part of the project area is highly vulnerable to landslide susceptibility whereas central and western part has moderate to low landslide susceptibility. Similarly, northern part has relatively lower susceptibility.

Table 3.5 : Percentage share of Landslide susceptible area

SN	Susceptibility class	Area Ha	Percentage
	Bareng Gaunpalika	**2065.58**	
	High	328.87	15.92
	Moderate	1336.65	64.71
	Low	400.05	19.37
		7,528.39	27.44

The slope in the area is steep (> 20 degree slope) in the lower elevation part and maximum area is above 20 degree slope, due to higher forest coverage landslide vulnerability is moderate in the project area. Settlement and road infrastructure distribution is dispersed to all over the project area and hence landslide vulnerability of settlement and infrastructure is also variable. Percent share and spatial distribution of different level of landslide susceptibility is presented in Figure3.12 and Figure 3.13 respectively.

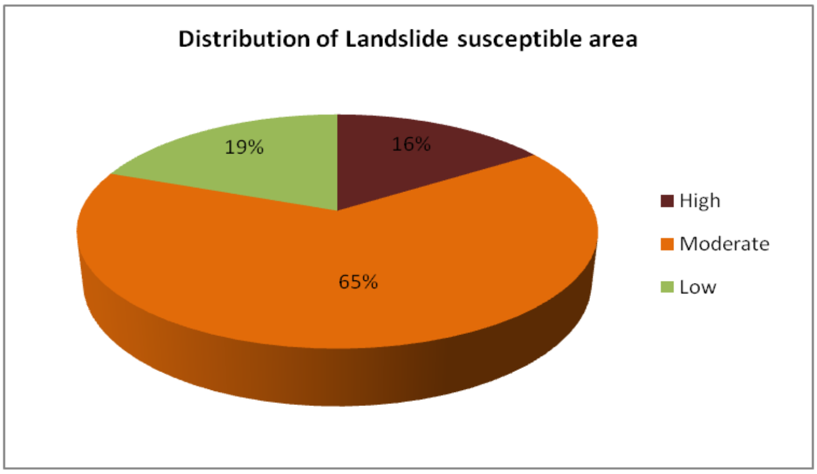


Figure 3.12: Landslide susceptibility in the project area

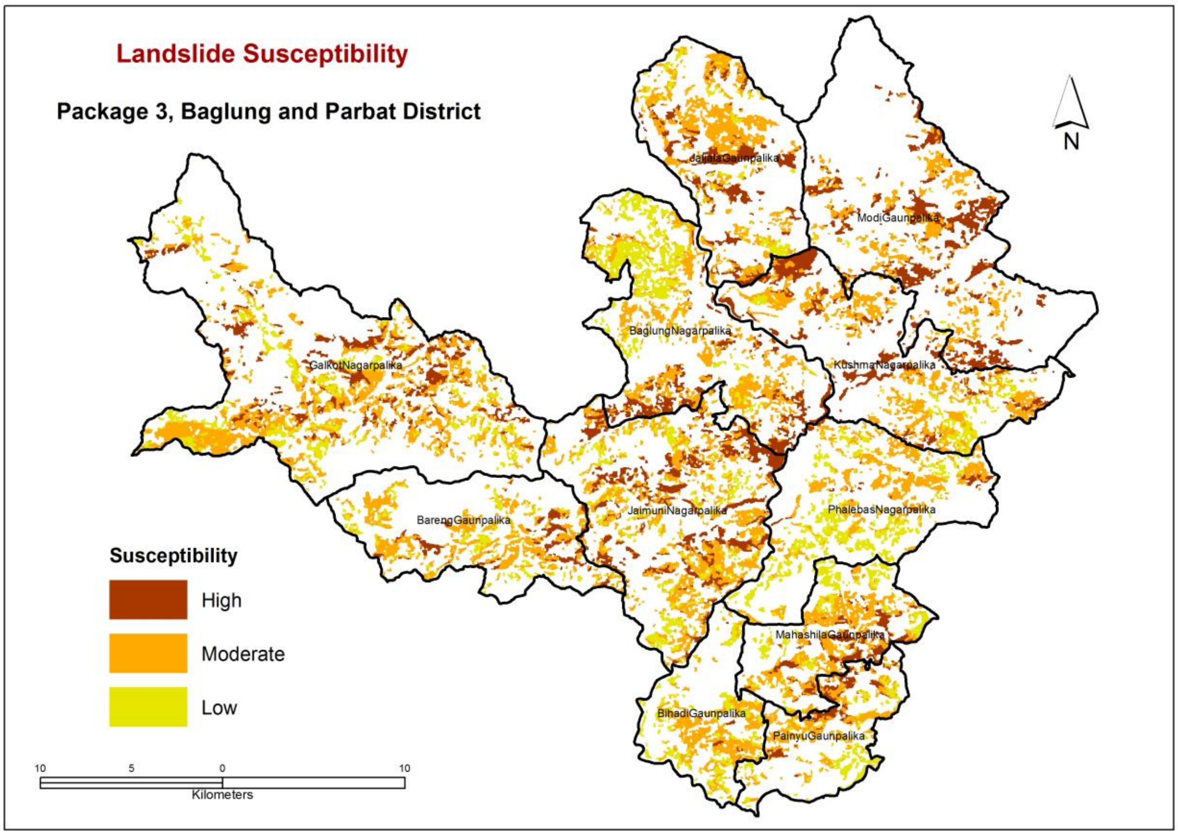


Figure 3.13: Landslide Susceptibility areas in Package 03

Soil Erosion:

The project area is composed of varying landforms, topography, slope, land use and soil. The soil erosion susceptibility is relatively low covering 13 percent of the total area. Table3.6 details the area under different soil erosion susceptibility class and Figure 3.14 shows the distribution of soil erosion susceptible area in the project area. Of the total soil erosion susceptible area, 11 percent area is under high susceptibility class covering more than 117 hectare while 85 percent area has moderate susceptibility. The southern and western part of the project area is vulnerable to soil erosion as compared to other parts of the project area.

Table 3.6: .Distribution of soil erosion in the project area

SN	Soil Erosion	Area Ha	Percentage
	Bareng Gaunpalika	**7528.39**	13.19
	High	117.92	11.88
	Moderate	853.71	85.99
	Low	21.12	2.13
		992.75	100.00

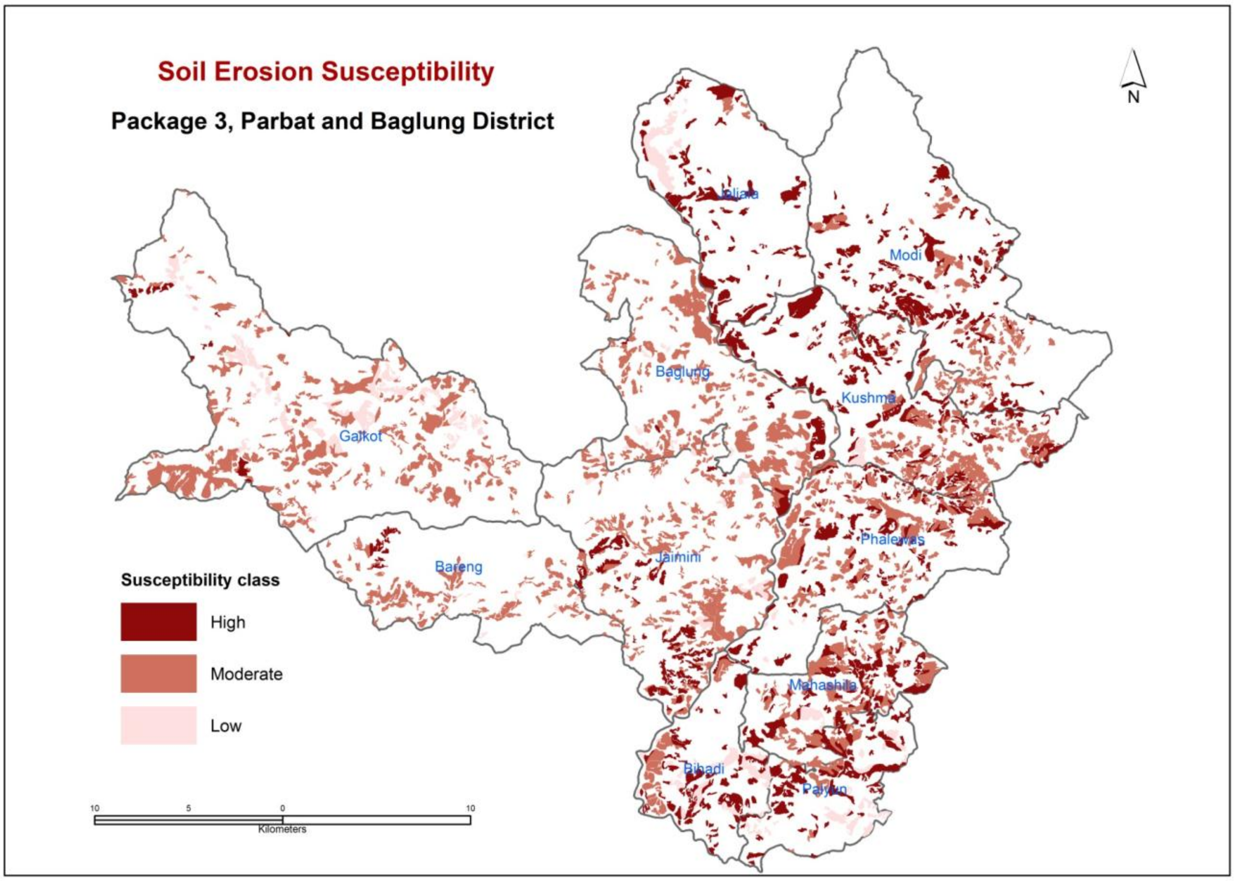


Figure 3.14: Soil erosion susceptibility in the project area

3.3.5 Discussion:

Landslide susceptibility zoning is based on assumption of continuous landslide density in space. Hence while land use planning and zoning, factors which minimizes landslide risks could be excluded such as in plain area and forest cover and slopes up to 15 degrees. Similarly in identified landslide susceptible area of varying degree, potential landslides may be of varying likelihood of occurrence based on management practices and protection measures in the area. The project area has relatively high forest cover with 50 percent though steep slopes is characteristic. North western and central-South part with moderate settlements and agriculture practices are vulnerable to landslide risk. Hence, conservation, management strategies and protection measures should be implemented for agriculture practices, settlement and infrastructure development.

The assessment of landslide susceptibility based on Multi criteria analysis in GIS environment indicate that there is a close relationship between slope, land cover land use and geology and landslide susceptibility. Beside, infrastructure construction mostly road construction in higher slope area with weak geology is another major factor along roadside landslide occurrence. A study by DWIDP in 2003 also reported that transport infrastructure in Nepal is heavily affected by landslide incidences every year. A field survey conducted in 2003 in arterial routes of Nepal, it was found that small- to medium-scale roadside landslides very often occur as partial landslips within existing large-scale landslides in the area. Therefore, considering greater and effective serviceability of existing transport infrastructure, better planning of newer transportation routes, and safe land-use planning, it is very important to understand the distribution pattern of large-scale landslides so as to mitigate the risk.

landslide record reveals that road and human settlement slopes are more vulnerable to landslides than ordinary natural slopes. This suggests that there is significant influence of human intervention, particularly in terms of road slope cutting, land development, agricultural practices, etc., on the occurrence of landslides and related failures in Nepal (Bhandary et. al., 2012). Nepal hazard risk assessment report 2011 states Slope, lithology, soil moisture, and precipitation are controlling factors for landslide hazard, while earthquake and rainfall are triggering factors. The report also highlights the paucity of data on the importance of earthquake triggered vs precipitation triggered in terms of fatalities may not be easily available. High severity zone areas are relatively governed by specific lithology condition and slope degree. Based on analysis, more than 20 % of geographical areas are prone to high landslides triggered by high intensity rainfall. Landslides typically occur in hilly areas and primarily affects the road sector. At the national scale, the damage caused by landslides is negligible in comparison to that caused by earthquakes, floods and droughts. These three disasters (earthquakes, floods and droughts) impact large geographical areas, covering almost all parts of the topography of Nepal.

An approach is required to integrate hazard maps developed by different organizations at suitable scale and used for disaster resilient development. The hazard risk map of particular area should be revised from time to time after major, extreme precipitation, and earthquake and major development infrastructure which may have affected.

Human activities such as changing pattern of land use, intensive farming, and excessive fertilizer use damage the soil and land. Housing development activities, infrastructure construction such as road need heavy earthworks, cuts resulting change and loss of soil and if not enough attention is paid to rainwater flow management and maintenance will in long run results soil erosion. Different cropping systems produces different rate of soil erodibility (Kunwar, Bergsma & Shrestha, 2016). A selection of the cultivation system that reduces erosion most effectively could be suggested based on soil erosion susceptibility assessment.

3.4 Seismic Risk

Nepal lies within the seismic hazards zones of the world. The Himalaya seismicity, in general, owes its origin to the continued northward movement of Indian plate after the continental collision between Indian plate and Eurasian Plate. The magnitude, recurrence and the mechanism of continental collision depend upon the geometry and plate velocity of Indian plate in relation to southern Tibet (Eurasian Plate). Recent result suggests that the convergence rate is about 20mm/ year and the Indian plate is sub-horizontal below the sun-Himalaya and the Lesser Himalaya.

3.4.1 Data

The analyzed data has been taken from the secondary sources. The data has been produced by a maps of epicenter of the Earthquake in Nepal Himalaya, Probabilistic seismic hazard assessment map of the Nepal Himalaya (Figure 3.15, Pandey et al. 2002), and seismic zonation of map the Nepal Himalaya (Figure 3.16, National Society for Earthquake Technology-Nepal (NSET).

The Bareng Gaunpalika lies in the seismic gap (Figure 3.17), which is highly risk and probability of earthquake. The seismic zone of Bareng Gaunpalika is 1.0 (Figure 3.18).

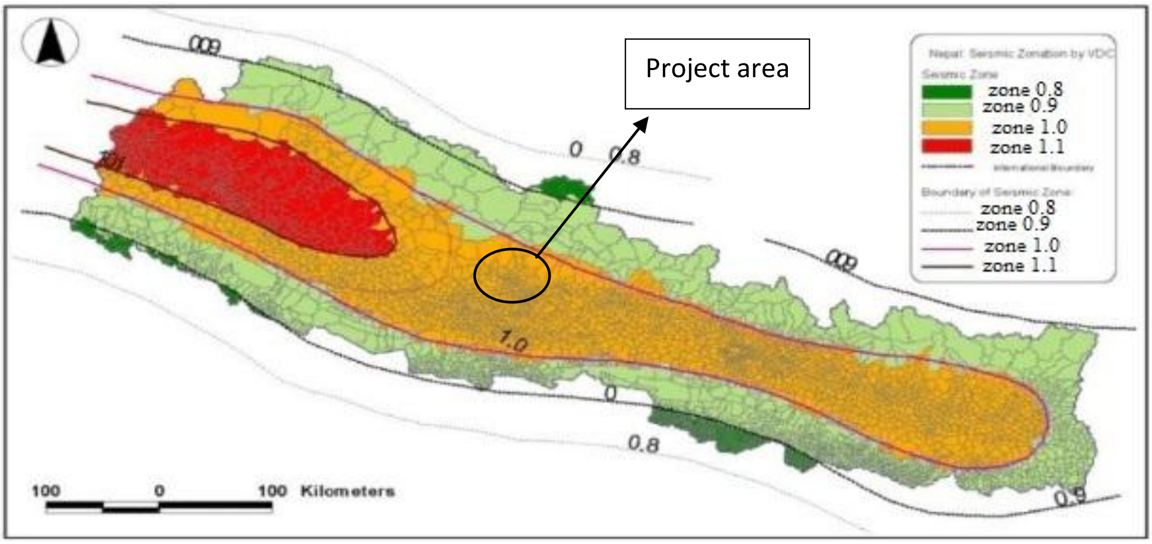


Figure 3.15: Seismic zoning map of Nepal with the lowest governance unit in different seismic zones

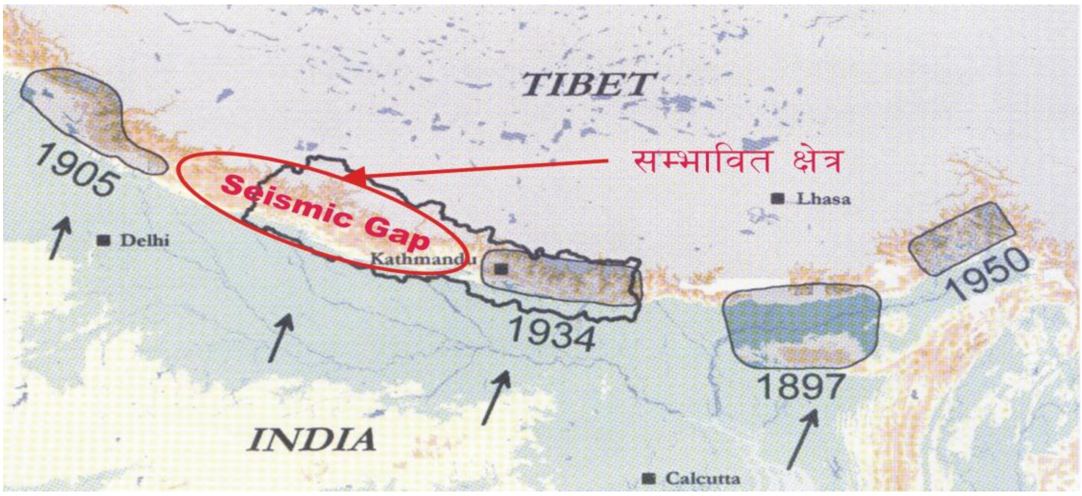


Figure 3.16: Map shows that the present area lies in the seismic gap of the region.

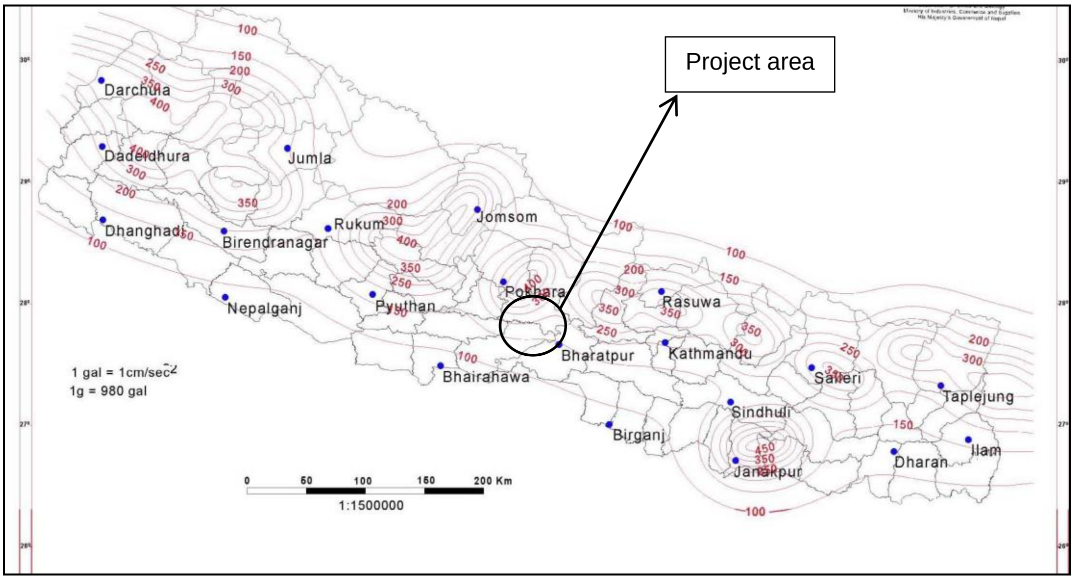


Figure 3.17: Probabilistic Seismic Hazard Assessment Map of the Nepal Himalaya

3.4.2 General Approach and Methodology Framework

The seismicity deals with the preliminary investigation of maximum credible earthquake and seismic coefficient of the project area. The result of micro seismic investigation, geodetic monitoring and morpho-tectonic study of the central Nepal has depicted that the more frequent medium sized earthquakes of 6 to 7 magnitudes are confined either to flat decollment beneath the lesser Himalaya or the Upper part of the Middle crustal ramp. The ramp is occurring at about 15 km depth below the foothills of the Higher Himalaya in the South of MCT surface exposures. Beg events of magnitude greater than eight are nucleated near the ramp flat transition and rupture the whole ramp-flat system up to the blind thrust (MBT) of the Sub- Himalaya (Pandey et al. 1995)

Preliminary seismic hazard assessment of the country using Gamble's third asymptotic extremes with the instrumental seismicity database of ISC is carried out by Bajracharya (1994) for different return periods 50, 100, 200, and 300 years, Attenuation model with mean value of McGuire and Oliveira is used for Horizontal acceleration.

Return period (years)	Peak horizontal acceleration (g)
50	0.10
100	0.15
200	0.20
300	0.25

Several seismicity studies have been carried out for the various projects in the country during the engineering design phase and seismic design coefficient have been derived for the project. There are several methods to convert the maximum acceleration of the earthquake motion into the design seismic coefficient. Generally three methods are commonly used to establish the seismic coefficient. These are:

i. Simplest method
ii. Empirical Method
iii. Dynamic analysis method using dynamic model

The effective design seismic coefficient is determined by using the simplest method, the following equation:

$A_{eff} = R^* A_{max}/980$

Where A_{eff} is effective design seismic coefficient
R= Reduction factor (empirical value R=0.50-0.65)

The result obtained from this method is found to be similar in the recent studies carried out by using the dynamic analysis and the static analysis. Therefore, this method is considered to be the most common method to establish the design seismic coefficient at present.

The third method is the dynamic analysis method using the dynamic model. This method is considered to be the most reasonable method at present. However, to apply this method parameters like the design input motion, the soil structure model, the properties of the rock materials have to be known, and therefore, it means that a detailed study is required to use this method. Therefore, the empirical method is considered to be the best to establish the design seismic coefficient for this level of the study.

The effective design seismic coefficient is determined by using the simplest method, the following equation:

$A_{eff} = R^* A_{max}/980$

Where A_{eff} is effective design seismic coefficient
R= Reduction factor (empirical value R=0.50-0.65)
Maximum acceleration A_{max}= 200 gal according to seismic hazard map of Nepal

The result obtained from this method is found to be similar in the recent studies carried out by using the dynamic analysis and the static analysis. Therefore, this method is considered to be the most common method to establish the design seismic coefficient at present.

3.4.4 Results

The result obtained from this method is found to be similar in the recent studies carried out by using the dynamic analysis and the static analysis. Therefore, this method is considered to be the most common method to establish the design seismic coefficient at present. The calculated effective design coefficient of Bareng Gaunpalika is considered as 0.3520.

3.4.5 Discussion

The Bareng Gaunpalika lies in the seismic zone which is high seismic hazard area (Figure 3.17) is vulnerable in terms of seismic activities in comparison to other parts of Nepal. However, the project area lies in between the two major thrusts i.e. Main Boundary Thrust (MBT) and the Main Central Thrust (MCT) certainly have threats of seismic activities in future. This shows that a due consideration is required before planning the large scale projects like hydropower development, tunnel construction, reservoir development, highway construction, large irrigation projects and landslide mitigation techniques. That’s why geotechnical considerations are the must before starting any kind of development activities in the area.

3.5 Industrial Risk

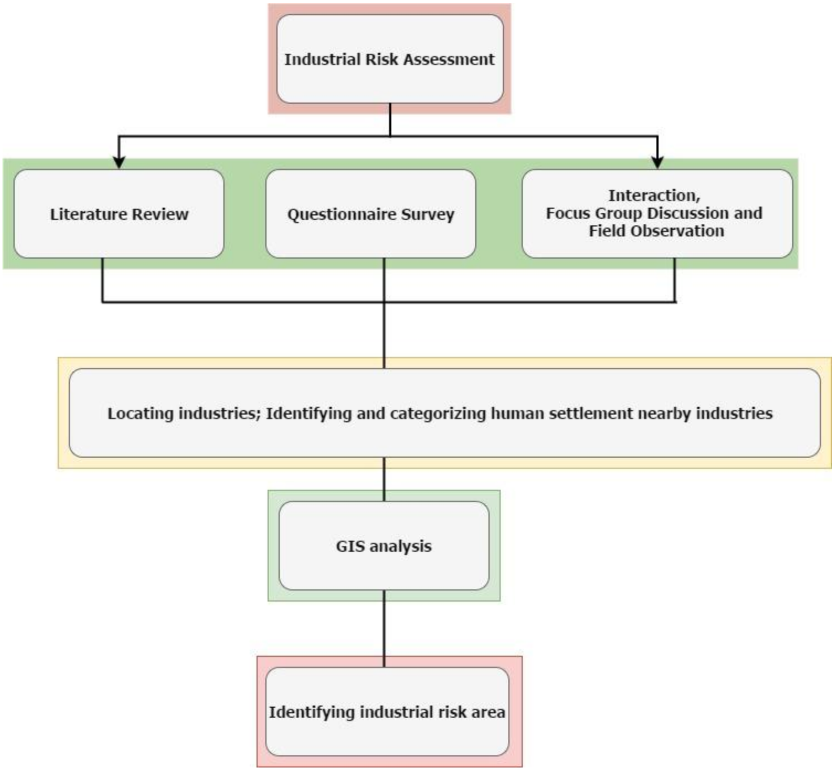
3.5.1 Data

Attempts have been made to identify the risk areas based on the location of industries, human settlements, buffer analysis in ArcGIS, survey of building materials and observation of building density, and socioeconomic status of the residents, etc. The present study has identified the industrial risk areas by collecting data through literature review, GIS analysis, consultation with local communities and field observation.

7.5.2 General Approach and Methodology Framework

General Approach: The general approach for the industrial risk layer data collection are as follows:

- Location of industries nearby the human settlements and river bodies that may relate to industrial risk
- Identification and categorization of settlement patterns such as clustered, moderately clustered, and scattered
- Identification of high-risk settlement areas by identifying entities of industrial risk
- Identification of industrial risk with a holistic approach, taking various risk entities into consideration
- Identification and delineation of the industrial risk area



7.5.3 Methods

The following methods were adopted for the gathering of data and information related to industrial risk:

Literature Review

The relevant information was collected from available literature in the form of books, reports, and maps of topography, land use, cadastral survey, and aerial photographs. Further information was also acquired from various websites.

Field Investigation

A detailed field study was conducted in the Gaunpalika by a multidisciplinary team, which comprised risk expert, environmentalist, geographer, forestry expert, agriculturalist, biologist, and socio-economist. During the visits, information on the basic components of human settlements, industries, forest, petrochemical stations, etc was collected that has been used to establish baseline data and used for the industrial analysis of the Municipality.

Questionnaires Survey and Informal discussion

The data on the industrial risk of the project Municipality were gathered through household surveys with questionnaires. Extensive consultation with government representatives at various levels, experts and professionals, local communities and industrial stakeholders was also carried out.

Informal discussions were held in the Municipality to interact with its local people and industrial stakeholders to collect information on the industrial risk of the Municipality. Direct observation (walkover survey) was carried out to gather information about industrial risk entities.

GIS analysis

The GIS functions including the buffer analysis and spatial analytical technique for assessing proximity (within a certain distance) of industrial areas from the location of human settlements were used for the purpose of evaluating industrial risk areas of the Municipality. In this method, a buffer zone has been defined at a pre-defined distance to create the various block groups. These buffer zones were used to describe the characteristics of the population inside each zone and the risks inherent due to the industrial location.

7.5.4 Result

According to the field survey and Focus Group Discussion (FGD), it has been found that Bareng Gaunpalika has majority of its area in a rural setting and there are no any major industries or businesses within the Gaunpalika. There are few small scale industries and businesses including mills, retail shops, butcher shops, small hotels, tailoring shops within the Gaunpalika. Due to the absence of the major industries, Bareng Gaunpalika has a low risk related to the industries.

7.5.5 Discussion

The risks from the industries in Bareng Gaunpalika are minimally negative in nature, for long-term duration and low in magnitude as none of the industries are of large scale. As stated above, the majority of the small scale industries are agro based. The agro based industries generate effluents and solid wastes that need to be disposed in an environmentally acceptable manner. However, there is a marginal risk of air pollution and water contamination from wastewater generated by those industries as the industrial discharges end up in surface water, causing a risk on flora and fauna, as well as on human beings, who use the surface water.

In concurrence with the regulatory requirements, the industries need to adopt a sustainable approach to the waste management. The effluents generated by agro-based industries are biodegradable and non-toxic and treated by physical, chemical and biological processes. With the application of appropriate technologies, it is possible to minimize the pollution and also to recover the water and other useful materials from the waste streams.

The best way to reduce the industrial risk would be a land use planning and zoning. Industries need to abide by the environmental rules and regulations and other statutory provisions of the Government of Nepal. The discharges from the industries need to meet the requirements of quality standards as set up by the Government of Nepal. To assure the public and concerned stakeholders about the minimization of industrial risk, the Government of Nepal needs to initiate an effective monitoring system and its thorough implementation.

CHAPTER 4
RISK IN THE STUDY AREA

4.1 Existing Risk in the Study Area

Flooding, Landslide and soil erosion are main risk observed in the Bareng Gaunpalika (package-03), Baglung district. Floods are not frequent in the Gaunpalika; however, there is a chance of landslide and erosion. From observations it seems that areas around small rivulets and other small streams are the most flood and landslide prone areas. Apart from the built-up areas, the risk of forest fire is very high during the hot-dry. However, Bareng Gaunpalika has mostly community-managed forest; therefore, risk of a forest fire could be low. The area under package-03 does not have any large-scale industries. Most of the industries in the Gaunpalika are agro-based processing; therefore, their impacts on human seems low.

Besides above, there are other natural and anthropogenic factors that produces risk and/or hazard. Drought, lightning, hailstone and wind, agricultural diseases and pest are other risks in the study area but their extent and intensity is relatively low.

4.2 Potential Risk in the Study Area

Flood, landslide and soil erosion are most occurring and potential risks in the study area. Both flood and landslide hazard may affect to the river bank area and erodes the banks, therefore, it may affect to the settlements as well as cultivated land and infrastructure particularly during the monsoon period. Many landslide and flood hazard can be at northern side of the Gaunpalika. In terms of seismic hazards, according to Bajracharya (1994), the Gaunpalika area falls in the seismic medium hazard zone of the Nepal Himalaya. Agriculture diseases and pest, heat wave, hailstone, frost etc. are also potential risk in the study area but their extent and magnitude is relatively low and in the local level.

4.3 Risk Data Model

The risk developed for Risk data is shown in Table 4.1.

Table 4.1: Risk Data Model

Field	Data Type	Description	Remarks
OBJECT ID	Object	Feature	
SHAPE	Polygon Geometry	Geometric Object type	
RISK ID	Short	Unique Object ID	
RISK Type	Text	1. Flood Risk	
		2. Fire Risk	
		3. Landslide Risk	
		4. Seismic Risk	
		5. Industrial Risk	
RISK LEVEL	Text	High	
		Medium	
		Low	
NAGARPALIKA	Text	Nagarpalika Name	
DISTRICT	Text	District Name	
REMARKS	Text	Any remarks regarding the feature	

SHAPE LENGTH	Double	Meter	
SHAPE AREA	Double	Area in m^2	

4.4 Risk GIS Database

The attribute of risk in the feature database is shown in 4.2. With this geo-database, the risk maps were generated.

Table 4.2: Risk GIS Database

S.N.	Description	Level 1	Level 2	VDC	District	Remarks
1	Fire	Fire	High Medium Low	Name of Nagarpalika	Name of District	
2	Flood	Flood	High Medium Low	Name of Nagarpalika	Name of District	
3	Landslide	Landslide	High Medium Low	Name of Nagarpalika	Name of District	
4	Seismic	Seismic	High Medium Low	Name of Nagarpalika	Name of District	
5	Industrial	Industrial	High Medium Low	Name of Nagarpalika	Name of District	
6	Other	Other	High Medium Low	Name of Nagarpalika	Name of District	

CHAPTER 5: CONCLUSIONS

Conclusions

Land use zoning is an essential planning tool for successful and systematic disaster risk reduction. It can reduce the vulnerability of people and infrastructure identifying appropriate locations for settlement and construction by applying adequate building standards during implementation of plan. Flood, landslide, fire, industrial and earthquake are major events that expose into vulnerability and hazard associated with risk. Among others, landslide and flood risks are high in the Gaunpalika as compared with other risks/hazards. Central and Northern part of the Gaunpalika area are most vulnerable to flood and landslides, hence proper management strategies and protection measures should be implemented for agriculture practices, settlement and infrastructure development.

5.1. Recommendation

Based on the present experience of the project, the following recommendation are made for future undertaking of similar projects:

- Integration of hazard maps developed by different organizations at suitable scale is required, and used for disaster resilient development policy. And that hazard risk map (of particular area) should be revised from time to time after major, extreme precipitation, and earthquake and major development infrastructure which may have affected.
- Fire preparedness activities most be carried out, which includes spreading messages through television, radio, street drama, video, folk songs, drills, posters, pamphlets, and hoarding boards to reduce the risk of firing.
- The seismicity factor should be considered in the detail engineering design.
- The risk layer maps and database may be useful for land use planners and environmentalist for the development intervention. Therefore, it could also be useful for preparation of environmental planning, policies and strategies to the Gaunpalika.

REFERENCES

AGS (2007). Guideline for landslide susceptibility, hazard and risk zoning for land use planning. *Australian Geomechanics*. Vol 42 No 1. Australian Geomechanics Society, Landslide Zoning Working Group, Australia.

Akiba C, Amma S, Ohta Y (1973) Arun river region. In: Hashimoto S, Ohta Y, Akiba C (eds) Geology of the Nepal Himalayas. Himalayan Committee of Hokkaido University, Japan, pp 13-33.

Bajracharya, R. B. (1994). Preliminary seismic risk evaluation of Nepal, Diploma thesis submitted to the International Institute of Seismology and Earthquake Engineering, Japan.

Bordet P. (1961) Researches geologiques dans l'Himalaya du Nepal, region du Makalu. Paris (CNRS)

Brooks, N. (2003). Vulnerability, Risk and Adaptation: A Conceptual Framework. Tyndall Centre for Climate Change Research, Norwich.

Brunner, G. (2010). HEC-RAS river analysis system, Hydraulic reference manual, Version 4.1. *US Army Corps of Engineers Hydrologic Engineering Center, Davis CA*, (January), 1–790.

CBS (2011). National Population and Housing Census (National Report). Vol. 1. Kathmandu: Central Bureau of Statistics.

Commission of the European Communities. (2006). Proposal for a Directive of the

Directorate, U. D., Government, P. W., & Disaster, A. (2013). Guidelines for Mainstreaming Disaster Risk Reduction into Land Use Planning for Upazilas and Municipalities in Bangladesh, (December).

Dixit, A. (2010). Climate change in Nepal: Impacts and adaptive strategies. Institute for Social and Environmental Transition, Kathmandu, Nepal.

DMG (2002). Geological map of Petroleum Exploration, Department of Mines and Geology.

European Parliament and of the European Council on the assessment and management of floods. {SEC (2006) 66}; pp.1-5.

Fell, R., Ho, K.K.S., Lacasse, S. and Leroi, E. (2005). A framework for landslide risk assessment and management. *Landslide Risk Management.* Hungr, O, R Fell, R Couture and E Eberhardt, Taylor and Francis, (Eds) London,3-26.

Friesecke, F. (2004). Precautionary and Sustainable Flood Protection in Germany – Strategies and Instruments of Spatial Planning Precautionary and Sustainable Flood Protection in Germany – Strategies and Instruments of Spatial Planning.

Hagen T (1969) Report on the geological survey of Nepal. Volume 1: Preliminary Reconnaissance. Denkschr.Svhweiz Naturf. Gessell., Bd 86:1-185 p.

Hua, J. P., Liang, Z. M., & Yu, Z. B. (2003). A modified rational formula for flood design in small basins. *Journal of the American Water Resources Association*, *39*, 1017–1025. Retrieved from <Go to ISI>://000186238800002 IHDPUp-date01_02_bohle.html>, 12 September 2006.

K Subramanya.(2006). Engineering Hydrology, 24th reprint, Tata McGraw-Hill Publishing Company Linited,New Delhi.

Kute S, Kakad S, Bhoye V, Walunj A. (2014). Flood modeling of River Godavari using HEC-RAS. Int J Res Eng Technol 03(09):81–87.

Kute, S., Kakad, S., Bhoye, V., & Walunj, A. (2014). FLOOD MODELING OF RIVER GODAVARI USING HEC-RAS, 81–87.

Manandhar, B. (2010). FLOOD PLAIN ANALYSIS AND RISK ASSESSMENT OF LOTHAR KHOLA.

Map, F. H., Body, M. P., Map, F. H., Map, F. H., Map, F. H., Conditions, B., Map, H. F., et al. (2003). FHM.

MOHA. (2013). Nepal Disaster Report, 2013. Ministry of Home Affairs (MOHA) and Disaster Preparedness Network Nepal, Government of Nepal.

MoHA (2011). *Nepal Hazard Assessment Part 1: Hazard Assessment*. Government of Nepal Ministry of Home Affairs, Asian Disaster Preparedness Center (ADPC), Norwegian Geotechnical Institute (NGI),Centre for International Studies and Cooperation (CECI)

MRE (1991). Mountain Risk Engineering Handbook: Vol I, Dhital, M. R., Deoja B.B, Thapa, K; Wagner, A.
NGI, 2004. Landslide hazard and risk assessment in Nepal - A desk study. NGI Report 20041239-1. Norwegian Geotechnical Institute (NGI).
Noti. 921/55, The Uttar Pradesh Brick Kilns (siting criteria for establishment) Rules, 2012, Uttar Pradesh Shashan, Prayavaran Anubhag, June 27, 2012
Pandey, M. R., R. P. Tandukar, J. P. Avouac, J. Lave, and J. P. Massot. (1995). Interseismic strain accumulation on the Himalayan crustal ramp (Nepal), Geophys. Res. Lett., 22, 751-754.
Phillips, B. J. V, & Tadayon, S. (2006). Selection of Manning ' s Roughness Coefficient for Natural and Constructed Vegetated and Non- Vegetated Channels , and Vegetation Maintenance Plan Guidelines for Vegetated Channels in Central Arizona Scientic Investigations Report 2006 – 5108.
Prinos, P. (2008). Review of Flood Hazard Mapping. *Measurements*. Retrieved fromhttp://www.floodsite.net/html/partner_area/project_docs/T03_07_01_Review_Hazard_Mapping_V4_3_P01.pdf
Rijal, K. P. (2014). Comparative Study of Flood Calculation Approaches, a Case Study of East Rapti River Basin, Nepal, (15), 60–64.
Shahiriparsa, A., & Vuatalevu, N. Q. (2013). Introduction to floodplain zoning simulation models through dimensional approach, 978–981.
Shahiriparsa, A., Heydari, M., Sadehian, M. S., & Moharrampour, M. (2013). Flood Zoning Simulation by HEC-RAS Model (Case Study : Johor River-Kota Tinggi Region). *River Engineering*, *x1*(1), 1–6.
Stöcklin, J. (1980). Geology of Nepal and its regional frame. Journal of Geological Society of London, v. 137, pp. 1-34
Stőcklin, J; Bhattarai, K. D. (1977). Geology of Kathmandu Area and Central Mahabharat Range Nepal. Department of Mines and Geology Kathmandu, Nepal, 86p.
Tiwari, K.R. (2015). Disaster Management Policies and Practices in Nepal (Draft). Institute of Forestry, Tribhuvan University, Nepal.
UN/ISDR (International Strategy for Disaster Reduction) (2004). Living with University. SOURCE No.4/2006; pp. 8-14, 48-50.
Upreti, B.N., 1999. An over view of the stratigraphy and tectonics of the Nepal Himalaya. (Eds.) P. Le Fort and B.N. Upreti: Geology of the Nepal Himalayas: Recent Advances" Journal of Asian Earth Sciences (Special Issue), v. 17, p. 577-606.
Upreti, B.N. and Le Fort, P. 1999.Lesser Himalayan Crystalline Nappes of Nepal: Problems of their origin. Geol. Soc. Am. Bulletin, Special Issue. No.328, pp. 225-238.
Upreti, B.N., 1996. Stratigraphy of the western Nepal Lesser Himalaya: A synthesis. Jour. Nepal Geol. Soc., V.13, pp. 11-28.
Upreti B.N., 1995. The Lesser Himalayan Crystalline Nappes: Are they Exotic Slices? (Abstract). Jr. Nepal geol. Soc. Vol. 12, Sp. Issue, Abstract Volume, First Nepal Geological Congress, 1995.
Van Butsic, Maggi Kelly and Max A. Moritz (2015). Land Use and Wildfire: A Review of Local Interactions and Teleconnections. Department of Environmental Science, Policy and Management. University of California Berkeley, Berkeley, CA94720, USA.
Westen, C.J. Van. (n.d.). Introduction to Exposure, Vulnerability and Risk Assessment. Retrieved from URL: http://www.charim.net/methodology/51