Geo-disaster and risk sensitive land use planning in Nepal

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ABSTRACT

Geo-disaster and risk sensitive land use planning (RSLUP) are greatly interlinked and exposure to geo-hazards is expected to increase in Nepal due to its unique geo-physical settings (rugged topography and fragile geology), active seismicity, frequent occurrence of rainstorms and socio-economic conditions. The 1993 extreme weather event of central Nepal, 2014 catastrophic landslide at Jure in Sindhupalchowk district followed by 25th April 2015 devastating earthquake and 12th May 2015 strong aftershock clearly indicated that landslide, debris flow, flood and earthquake are critical threat because of the likelihood of massive loss of lives and infrastructures that particularly affecting in land use planning. The RSLUP is considered as emerging issues in Nepal and has being started to implement in municipality/rural municipality (Nagarpalika/Gaunpalika) levels which needs focus on spatial characteristics of geohazards and their assessment techniques. Appropriate geo-scientific techniques are indispensable to model various parameters that are associated with specific hazard and resultant risk. For example, HEC-RAS modelling is an efficient technique for flood hazard and risk assessment.

Keywords: Geo-disaster, Risk, Land use planning

INTRODUCTION

Scarce knowledge about real social impacts of geohazards and resulting disasters in many of the countries exist although they have a significant impact on their national economies (Mateos et al., 2017). Nepal is also a country implementing risk sensitive land use planning in municipality and rural municipality (Nagarpalika and Gaunpalika) level as emerging issues without due consideration of actual cause and characteristics of geo-disasters. There are no common guidelines and practices for geo-disaster assessment techniques and it is an urgent need to improve the basic technology to determine better evaluation of geo-disasters and inherent risks, and the land use planning to deal with them. Consequently, the monitoring of potential geohazard locations using long-term observatories led towards new research and development as well as pragmatic application in local level. The 1993 extreme weather event of central Nepal, 2014 catastrophic landslide at Jure in Sindhupalchowk district and the 2015 Gorkha earthquake are the major recent geo-disasters that evidenced the necessity of risk-based land use planning to protect the loss of human lives and development gains. Many natural disasters are aggravated by inappropriate actions and decisions. Therefore, land use planning is a major tool for reducing risks from natural hazards, in turn aiding sustainability and increasing resilience (Burby et al., 2000). Furthermore, risk-based planning provides an opportunity to move beyond planning for geo-disasters (i.e. the likelihood of an event) to planning for the consequences of an event which involves assessing the land use and having planning provisions that become more restrictive as the risk increases (Saunders and Kilvington, 2016). Integrating the practice of risk management within the governance, functions and operations of local authorities can effectively accomplish disaster risk reduction (World Bank and EMI, 2014).

GEO-DISASTER CHARACTERISTICS

Geo-disasters are recognized as a major threat for the society leading the scientific community into introducing various suitable methodologies for susceptibility, hazard and risk evaluation. The integration of these assessments into land use planning can significantly enhance the society resilience to geohazards. Exposure of Nepal to natural disasters every year and meeting the development strategies is extremely challenged by losses from different types of disasters. There are 1.06 reported events of disasters per day in average in Nepal causing the loss of lives and properties as well as damaging development infrastructures (Pokharel, 2006). In order to clarify the ways in which disaster and development interact, it is helpful to distinguish between the economic and social elements of human development. These components are interdependent and overlapping (UNDP, 2004).

A wide range of physiographical, geological, ecological, meteorological and demographic factors contribute to the disaster vulnerability in Nepal. Repeated occurrence of geo-disasters is a major challenge for development in Nepal that often causes devastating effects in terms of human life and economic losses. The mechanisms and controls on ground deformations leading to geohazards are not straight forward to understand in the complex terrain of the Nepal Himalaya in terms of their distribution in time and space. Also, it is not impossible to control nature, human activity, its impact on the development, and the subsequent impact on vulnerability can be altered (Tianchi and Berhans, 2002). Thus, geo-disaster assessment requires cause and characteristics of different types of geohazards in regional and site specific level in order to implement risk reduction measure because the geology of the Nepal Himalaya is weak and in the phase of stabilization, even a small wrong development can cause the destabilization of the natural environment (Mulmi, 2009).

The characteristics of geo-disasters in Nepal vary with differential geomorphic terrains (Thapa, 2007). Flooding and landslides are the most dispersed geohazards in Nepal but they are spatially localized in particular geo-environments. In the high mountains, landslides and mudflows are frequent. The landslides in Nepal are densely distributed in close proximity to the major fault/thrust or linear boundary formed by competent and incompetent strata therefore, close proximity to geological structures like fault/thrust, fold (anticline/syncline) should be considered in effective land use planning. Many landslides in mountain hill-slopes are originating as planar slides at initiation point and converted into debris slide to flow which generally moves in down-slope with high velocity (Gerrard, 1994). Quite often landslides sweep away the whole village. The mudflows cover terraced land with boulders and debris damaging the crop and degrading the agriculture land. In the foothill and the floodplain, the rivers cause deposition of sediment (floodway zone) damaging crops and arable land. River bank erosion and inundation of land are also a serious problem in flood prone area. Subsidence hazard and risk are noticeable in carbonate rocks e.g. Armala village in Pokhara valley, west central Nepal.

Risk of geohazards can impact significantly on the social, environmental and economic costs associated with the use and development of land. Hazard and risk is always important component in land use planning because it plays key role to demarcate the safe and un-safe areas for settlements and any development programs. For example, a land unit is suitable for cultivation which may not be suitable from hazard and risk point of view. The knowledge of the relationships of development, land use and disaster risk provide planners a deeper understanding of what drives people to locate themselves in high risk area. In hazard and risk evaluation, following points to be considered: (a) identify areas that are of high risk from impacts of hazard, (b) find out areas for restricting location of human settlements and choosing suitable economic activities, (c) understand the area of land actually available for development (considering development is not allowed in areas prone to geohazards) and (d) provide guidance in formulating suitable risk reduction policies and zoning regulations.

RISK SENSITIVE LAND USE PLANNING

The process of mainstreaming disaster risk management parameters in land use planning is termed as risk sensitive land use planning (RSLUP). The RSLUP is a rather new practice – especially in developing countries and the RSLUP adds two new considerations to the conventional approach to land use planning (World Bank and EMI, 2014):

Disaster risk reduction parameters and objectives

Hazard, vulnerability and risk parameters are identified, collected and integrated with traditional land use planning information (e.g., socioeconomic profiles, demographics and transport networks), and disaster risk reduction (DRR) goals and objectives are formulated.

Integration through formal government activities

Measures are taken to ensure understanding, acceptance and support for the plan; to improve the competency and knowledge about risk-sensitive land use planning among planners and other professionals, and to raise the awareness and support of all stakeholders.

Risk information can be used as one of the basis to identify future directions and intensities of land uses. It begins with an assessment of natural hazards in relation to human and physical vulnerability, capacity and development (World Bank and EMI, 2014). Different types of hazards can exist and the prominent risks that may pose due to flood, fire, landslide, seismic and industrial. Based on detail understanding of relevant theories and literature conceptual framework, database development (collection and analysis) begins. The data required in planning is always a mix of the spatial and non-spatial, a blend of the qualitative and the quantitative, covering a wide range of physical, social and economic attributes (Harris 2001) i.e. data and information that need to be analyzed can be from various sources either in the primary or secondary forms. Risk layers are usually prepared based on visual interpretation of images and field-surveyed data which rely on geo-scientific principles. Methods to analyze different hazards differ from one to other, thus suitable method needs to be implemented in each case. Flood hazard and risk is effectively analysed by HEC-RAS modelling, landslide hazard by maximum likelihood function based on qualitative or quantitative approach. Proximity analysis is useful for industrial and fire risks. Seismic hazard can be obtained by analyzing the geological conditions and peak ground acceleration (PGA) or ground deformation parameters. Liquefaction potential analysis needs rigorous database and analysis depending on historical information as well as geology of particular site. In fact, the 2015 Gorkha earthquake did not release all stored energy because it was happened without forming the rupture surface indicating that geological hell of Nepal earthquake may not be over. Therefore, all municipalities and rural municipalities must be aware of anytime earthquake risk in future.

The analyzed hazard maps should be integrated in a multi-hazard map by utilizing spatial function of geographic information system (GIS). A flowchart to prepare the RSLUP map is shown in Fig. 1.

Trend analysis on population growth, land use change, urban landform, economic activities and expansion of physical infrastructure and prediction scenarios are required. The land use/land-cover trend analysis portrays what has happened in the past thereby allowing for a trajectory to predict what might happen in the future. The analysis is further enhanced by meaningful participation of stakeholders throughout the process so that the plan becomes enriched with inputs from stakeholders (World Bank and EMI, 2014). The spatial modelling demarcates the development of potential areas based on risk assessment, land use change and trend analysis. The incorporation of the risk assessment results into the decision process of the land use

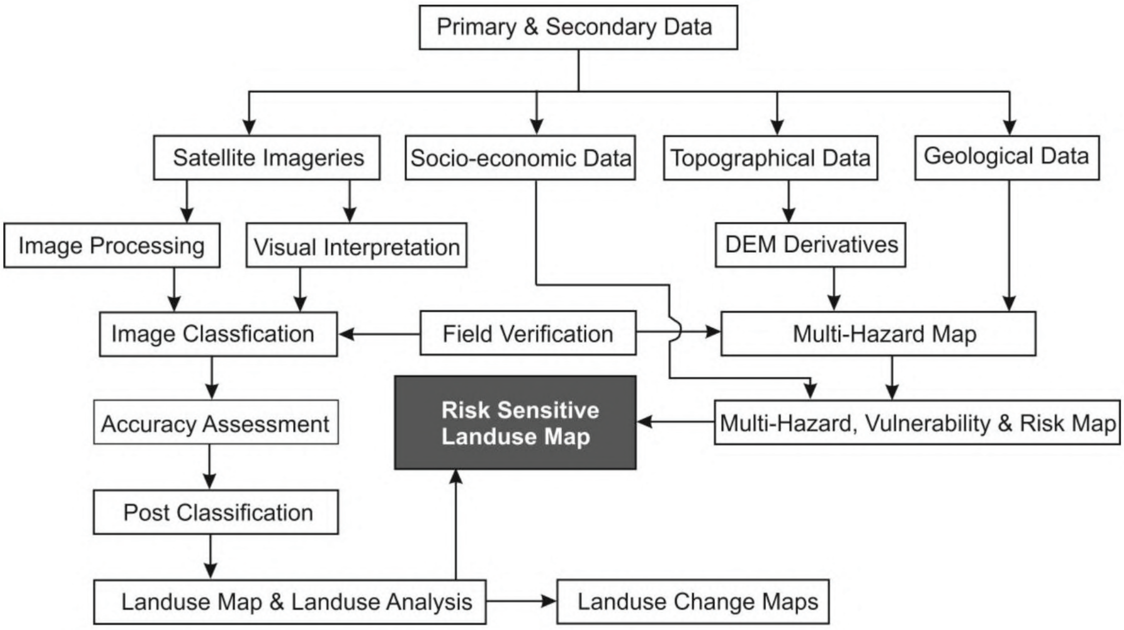

Fig. 1:Preparation of risk sensitive land use planning (RSLUP) map (modified after Rimal et al., 2015)

planning activities and should be backed by GIS maps which can be thematic and composite. The several thematic maps can be overlaid to determine the location of areas suitable for urban expansion. Present land use map, land capability map, population density map, infrastructure map, land use zoning map etc. should be crossed to calculate statistics of the overlaid maps. Calculated demographic characteristics and settlement patterns in trends analysis require to be verified whether the trends are proceeding towards safe or unsafe areas. Thus, final zoning of land use map is produced by incorporating the multi-hazard, vulnerability and risk maps. The obtained RSLUP map serves as the basis for the physical development and land use planning by predicting areas prone to hazards and their associated risks which is intended to guide the actions for reducing vulnerabilities (i.e. remedies for vulnerable settlements) and addressing risk through the recommended land use practices obtained from the zoning.

Concisely, a risk-based planning assessment can be used to address the effects of a particular natural hazard, either in its own right, with other hazards at the same location (i.e., cumulative), or with cascading hazards (e.g. an event such as an earthquake can trigger other hazards such as liquefaction, tsunami and landslides). It ensures that the economic, social, cultural, infrastructure, and health and safety consequences of a specific development can be explored and quantified as part of future planning decisions (Saunders et al., 2013).

CONCLUSIONS

Frequent occurrences of geo-disasters in the Nepal are attributed to rugged topography, differential geology, active seismicity, extreme weather events and human intervention. Damages and losses caused by geo-disasters have a significant impact on the national economies of the Nepal which had already been evidenced by incidences of past geo-disasters (1993 landslide and flood of central Nepal, 2014 Jure landslide and 2015 Gorkha earthquake etc.). It is necessary to develop common method to assess geo-disaster data and to analyze risk sensitive land use planning depending on specific geological settings with respect to tectonic activity, slope morphologies and other forcing mechanisms because the geo-disasters are generally localized in particular geological domains.

The risk-based land use assessment provides suitable planning from the consequences of geo-disasters for reducing risks and the three alternatives can be adopted to deal with disaster risk prone areas: (i) leaving the unprotected areas i.e. specifying the land use zoning for various developmental purposes, (ii) using reduction or protection measures in areas prone to high hazard and risk and (iii) prioritizing the buildings and infrastructures in terms of importance from the impact levels (high, medium, low). In addition, scientific literatures on geohazards are unknown by the planners or decision makers and the requirements of the planners are unfamiliar to geo-scientists. Thus, the good communication is required between geo-scientists and land use planners as well as awareness strategies have to be implemented at all levels in society more specifically people living in vulnerable areas.

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