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Review of Flood Hazards Studies in Nepal

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Abstract

Flood, a common water induced disaster of monsoon season, is the recurring phenomenon in Nepal. It causes many deaths and injuries besides severe impacts on the vital infrastructures of the nation. This paper reviews the published national and international journal articles related on flood hazard mapping in Nepal. Desinventar database from 1971-2016 shows that Bagmati province and province 2 are more affected than other provinces in Nepal. Here we review the previous studies on flood disaster at the regional and national level. The results show that most of the papers are based on steady flow model for inundation mapping and more focuses on hazard analysis rather vulnerability and risk assessment.

Keywords: Flood hazard, inundation, vulnerability, risk assessment.

Introduction

Rugged topography, weak geological formations, active seismic conditions, occasional glacier lake outburst, concentrated monsoon rains and unscientific land utilization are some of the major reasons for water-induced disaster in Nepal (DWIDP, 2013). Asia continent is much affected by floods and the countries like India, China, Philippines, Iran, Bangladesh and Nepal are extremely vulnerable (WWAP, 2006). Nepal is considered the second highest country at risk of floods in the South Asia (UNDP, 2009). Between 1954 and 2018, floods in Nepal caused 7,599 deaths, affected 6.1 million people and caused economic losses of about 10.6 billion USD. On average, 100 people were killed annually (EMDAT, 2019).

Nepal lies in second highest country at risk of floods in South Asia (UNDP, 2009). Regular flooding, predominantly in the monsoon season, results significant loss of life,

property, and livelihoods (NCVST, 2009). Between 1971 and 2011, floods in Nepal caused 3,329 deaths, affected 3.9 million people and caused economic losses of about US$5.8 billion. On average, 300 people were killed annually (MoHA, 2015; UNDP, 2009).

According to Dilley et al. (2005), Nepal falls in 11th position on disaster venerability in the world and half of its population is under the threat of four types of disaster at a time including flood. The problem of flood in certain plain areas in Nepal is very chronic. The majority of flood disasters' victims are poor people living in the flood plain. The expansion of urban areas and economic activities in flood plain is placing additional people and infrastructures at risk. Thus, resulting in changes in natural slope, river morphology and the drainage system, land use/land cover, the frequency in the occurrence of landslide and flood hazards, exacerbating the water induced disasters.

Methods and Materials

Flood disaster overview in Nepal

Frequent floods, usually in the monsoon season, result significant loss of life, property and livelihoods (NCVST, 2009). Nepal has very high risk of floods. The flood history of 1993 floods in Central Nepal, 2008 Koshi embankment breach floods, and the 2013, 2014 and 2017 floods in the mid- and far-western regions caused not only immense loss to both human life and property but also had a devastating impact on development.

The desinventar database from (1971-2016) shows that a total of 4,160 flood events were recorded during 45-year human losses with damages are common to all provinces in Nepal. Figure 1 shows that the number of events has been recorded highest in province 2 26.47 % whereas Karnali province have comparatively low (4.83%). Similarly, in terms of human death and losses Baghmati province and province 2 have higher (54.47%) than other provinces. The figure 1 also shows that the percentage of human injury due to flood disaster recorded high in Bagmati province (34.15%). In terms of house damage, disaster statistics maintained by desinventar reveal that 98,818 houses were damaged during the 1971-2016. It shows that the most of the buildings were destroyed in province 2 (45.34%) with 70%, people were affected due to flood disaster. The estimated economic losses due to flood events also high in province 2 (45.14%) total of 3335.36 million rupees.

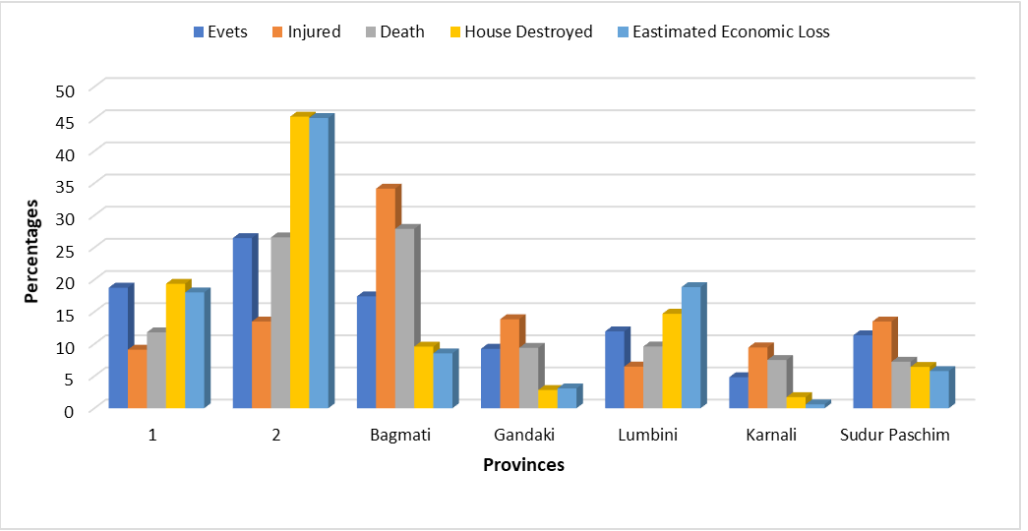

Figure 1. Damages and losses by flood in percentage by province

Nepal is highly susceptible to a range of hydro-meteorological and geophysical hazards. Steep and rugged mountain topography together with fragile geology, active tectonics, and extreme weather has made the country prone to multiple natural hazards. The country is landlocked bordering with India on the East, West and South, and China on the North. Nepal is situated in the middle portion of the Hindu Kush Himalayan (HKH) Region (Figure 2). Nepal has three distinct types of rivers. The first type includes three big perennial rivers – Koshi, Narayani, and Karnali – originating from the high Himalayas, with some of their tributaries originated in Tibet. These rivers are fed by the glaciers, snowmelt, and rainfall in the Himalayas and flow down to India through the lower hills and Tarai plains of Nepal. The second category rivers are also perennial but originate from the middle mountains of Nepal that flow down to the lower plains of Nepal and India. These rivers have very high variation between the dry and rainy seasons. The third category of rivers often referred to as torrents or streams, originate from the Chure hills and Siwalik. These rivers are fed by the monsoon rains from June to September.

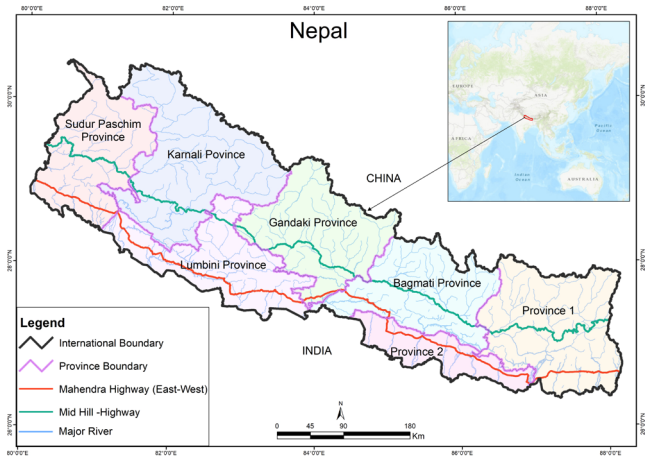

Figure 2. The study area

This is a review paper based on published articles related to flood hazard mapping in Nepal. The flood data from 1971-2016 were collected from NSET. The study is primarily based on online resources for data; that have accessed through google scholar, and research-gate. This paper reviews the published articles in national and international journal available in internet. Ten national journal's articles and four international journal articles were retrieved from research gate and google scholar. Scientific literatures were searched from journal articles starting from the year 2000 to the year 2020. Key words used to search the articles are: Flood and floods types, flood hazard assessment, flood vulnerability assessment, floods risk assessment, flood hazard mapping, GIS based flood hazard assessment, application of remote sensing and GIS for floods hazard mapping.

Results and Discussion

Many studies have been conducted to find out flood hazard mapping and risk assessment tools and techniques. There are several methods which have been used in Nepal in order to predict the flood in the river. Manandhar (2010) carried out a study in Lothar Khola basin using HEC RAS method with the help of recorded precipitation and river flow data of the basin. His prediction based on Log Pearson type II method shows high discharge in the future and vulnerability of the cultivated land due to flood.

Awal (2007) used hydraulic model and GIS for floodplain analysis and risk mapping of Lakhandei River. This study integrated the hydraulic model with the Geographic Information System (GIS) for the case study of Lakhandei River in Nepal. Most of the previous studies used steady flow model however, this study used both steady and

unsteady flow model for floodplain analysis. The study focused on the preparation of Triangulated Irregular Network (TIN) from available cross section data, contours and spot elevations, calculation of water surface profiles by steady and unsteady flow analysis, delineation of the flood areas and carried out flood risk mapping. The approach adopted for the study consisted of dividing the risk into vulnerability associated with land use pattern and hazard associated with hydrological and hydraulic parameters. The results of these analyses were combined to see relationships such as discharge-flood area and flood depth-land use and recommended to adopt an appropriate land use plan in flood prone areas encourage the community to be involved in the flood action plan to mitigate the flood hazard and improve their awareness on the negative consequences of flooding.

Dangol (2008) assessed the flood inundation problem in Blakhu Khola using Steady flow analysis which shows barren area near the river is susceptible to flood hazard, which indicates future human lives are more prone to disasters as those lands have gone through planning for future settlement. Mapping and assessing hazard in the Ratu watershed was done by Khanal, Shrestha, & Ghimire (2007). Three di□erent approaches were used in a flood risk assessment; namely, a geomorphic approach using GIS and RS, rainfall-runo□ processes using HEC-RAS model and social hazard mapping based on field survey. This study was used topographic maps, aerial photographs, satellite image, and household survey and, channel shifting and associated economic loss are the most serious disaster problems in the watershed. GIS-based software's, such as Arc View, ILWIS, HEC-RAS and HEC-GeoRas were used for data processing and analysis. It was found that 18% area is in high-risk category, and about 8% of the total annual household income is lost as a result of floods and also found nearly 61% of the households in the watershed are exposed to flood hazards, among them, 21% of the households were situated in high-hazard areas.

Gautam and Kharbuja (2006) carried out flood hazards maps of Bagmati River of Kathmandu valley. They prepared for various return period floods by using hydrodynamic modelling to compute the unsteady flow water level profile along the channel reach and they also interpolate flood water levels and to computed flood depth from digital elevation model (DEM). Adhikari (2013) had studied on flooding and Inundation in Tarai areas in Nepal. This article tries to highlight the issues and concerns of flooding and inundation in the Tarai and suggests measures to mitigate these issues in light of climate change adaptation. Devkota et al. (2013) have studied flood vulnerability through the eyes of vulnerable people in mid-western Tarai of Nepal. This paper intends to assess the perceived flood vulnerability through the eyes of vulnerable people at the community level in two southern districts namely Banke and Dang of Nepal.

Khanal (2004) studied floods in Madi River watershed central Nepal. It tries to highlights type, magnitude, recurrence interval of floods in Madi River and damages associated with it. This study shows that high magnitude destructive flood in the mountain areas are triggered by landslide and debris flow and downstream areas are highly affected by floods. Aryal, et al. (2020) have studied southern slope of Himalayas. They present comprehensive hazard mapping and risk assessments in the downstream region of the Karnali River basin for different return-period floods. They have used HEC-RAS to developed the flood inundation map for flood hazard and vulnerability analysis. The assessment was conducted on a 38 km segment of the Karnali river from Chisapani to the Nepal–India border. A total of 132 km of rural–urban roads and 22 km of highways were inundated during the flood.

Karki, et al. (2011) assessed flood hazards, their impacts and the resilience of communities at the watershed level. Flood danger level and warning level were identified using maximum instantaneous discharge data and gauge height. The results show that agriculture system of the study area in a geographically vulnerable position. Talchabhadel and Sharma (2014) studied west Rapti River based on real time data analysis. About 300 people lose their life each year due to floods and landslides in Nepal with property damage exceeding 626 million NPR on average. The real-time flood early warning system together with the development of water management and flood protection schemes play a crucial role in reducing the loss of lives and properties in the basin. Basically, this paper presents an overview of flood problems in the West Rapti River basin, causes and consequences of recent floods and the applicability and effectiveness of the real time data to flood early warning in Nepal.

Thapa, Shrestha, Lamichhane, Adhikari, and Gautam (2020) have studied on Khando catchment in eastern Nepal. This study focuses to quantify the hazard and vulnerabilities across one of the frequently flooding catchments Khando River and conducted flood hazard assessment for 20, 50, 100, and 200 years return periods. They have done coupled flood hazard analysis with vulnerability analysis of the most dominant construction system along the river channel wattle and daub houses. Based on the measured inundation depths, they have created vulnerability and fragility functions. Tamang and Tamrakar (2017) studied Malekhu khola in central Nepal. This study prepared flood hazard maps using GIS and HEC-RAS. It was observed that the downstream portions are comparatively more affected by the flood rather than the upstream section. There is only a slight change in the flood prone area at different return periods. Basnyat, et al. (2020) studied the post-flood assessment of the July 2019 flood in Bagmati River Basin and adjacent districts in Nepal. It analyses the hydro-meteorological conditions that led to the flood hazard, and the various factors in terms of vulnerability and exposure of the affected communities, infrastructures and other assets that suffered from damages and losses (risks).

Most of the reviewed literatures have focused on one-dimension (1D) steady flow model using HEC RAS and Arc GIS software for flood modeling. Only few literatures studied using statistical method and 1D unsteady flow model.1D steady flow model could not provide fine result for all regions. For this two-dimensional (2D) unsteady flow model and other statistical model should be study for flood modeling. Most of the papers focused on flood inundation mapping to prepare hazard assessment but only very few papers tried to assess the flood vulnerability and risk assessment.

Conclusion

The use of GIS and remote sensing tools with one dimensional hydro modeling tool HEC-RAS and Geo Hec-Ras is highly used. The desinventar data reveals that Nepal lost huge amount of economic losses as well as human lives. The applications of hydraulic model and GIS for floodplain analysis and risk mapping have been limited in countries like Nepal, where the availability of the river geometric, topographic and hydrological data is also very limited. The situation of river flooding in Nepal is also completely different, as there is much higher variation in the river flows and rivers are completely unregulated. The use of satellite remote sensing technology will be highly applicable in flood hazard and risk mapping.

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