Government of Nepal
Ministry of Energy, Water Resources and Irrigation
Water Resources Research and Development Centre
Pulchowk, Lalitpur

WRRDC RESEARCH LETTER

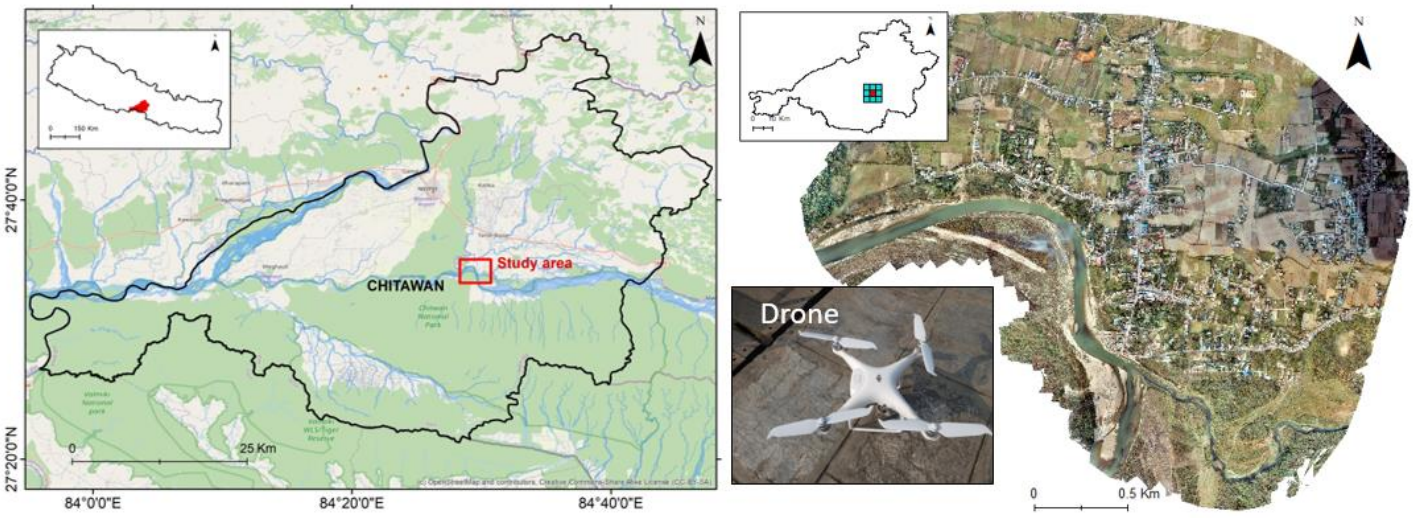
Issue: 10
July 2021

Settlement-scale flood hazard mapping and vulnerability analysis of buildings

Introduction

As settlements are usually established parallel to the river channel, it is obvious that the areas with low reliefs would be easily affected by flooding. The annual torrential precipitation, haphazard urbanization, loss of forest land cover, river channel shifting, sedimentation and erosion, among others contribute primarily in flooding. Owing to the fact that flood damage to structures, lifelines, and socio-economy would result in enormous losses, it is pertinent to encapsulate flood vulnerability of structures and infrastructures with flood hazard mapping. As studies so far are largely confined to flood hazard mapping and modeling but in local scale, studies comprising cross-disciplinary perspectives including flood hazard mapping, zonation, and built-environment vulnerabilities have not surfaced yet. However, in the end, flood may affect the structures and lifelines and losses attributed would be directly affecting the public which demands a cross-disciplinary study in local or settlement scale to reassure resilience in community level.

The study area is the Sauraha region in Ratnangar Municipality ward no 6 of Chitwan district. Sauraha is a popular town that lies on the edge of Chitwan National Park. Being at the bank of the East Rapti river, it faces frequent flooding resulting in huge losses of property. The floods in the East Rapti river block the water in local drainage and its tributaries – Dhungre Khola and Budi Rapti and inundate the entire area.



Objective

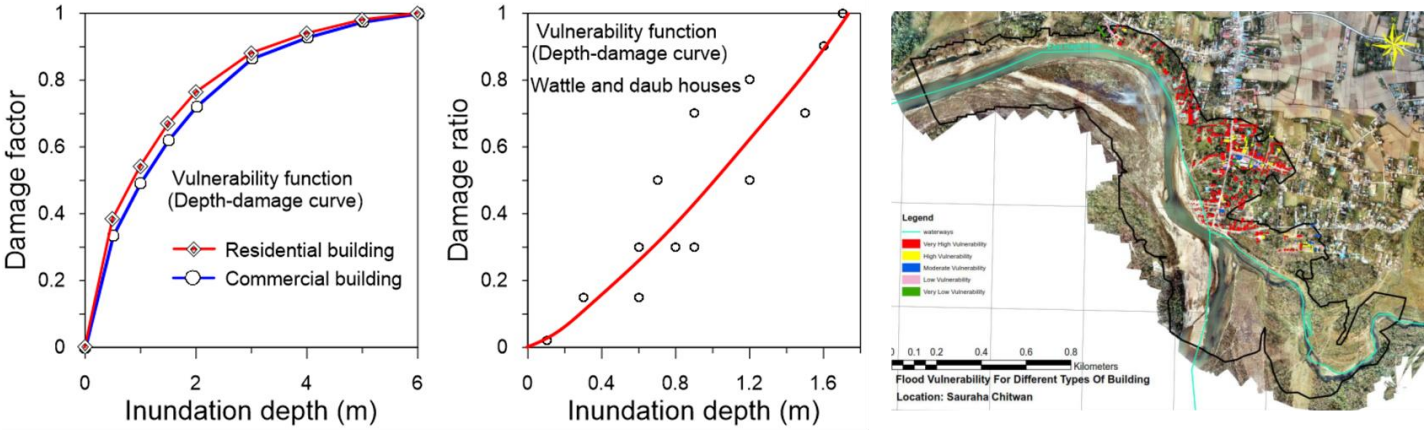
The generic objective of this study is to obtain flood hazard maps and implement the same in flood vulnerability of lifelines. Cross-disciplinary implication of this study is expected to provide a rational and calibrated method to replicate in the future too.

Materials and Method

Hydrological, structural and infrastructure vulnerability analyses were conducted. Hydro-meteorological data was obtained from Department of Hydrology and Meteorology. A digital elevation model (DEM) was created from drone survey data. Ultimately, hydrological modeling was performed using HEC-RAS and HEC-GeoRAS models. At least four return periods including 100 years was considered for scenario modeling and mapping purpose. The flood inundation maps were prepared, and zoning was done considering a continuous interval scale of flood inundation levels. Similarly, information on individual buildings and infrastructure was taken from the study area. GPS survey was conducted to obtain the spatial information. Thereafter, vulnerability functions (depth-damage curves) were formulated either empirically. Empirical models as reported by Gautam and Dong (2018) was opted to have better precision.

Results

Broadly, three major types of buildings can be found at Sauraha. A generic classification approach adopted after field investigation led to categorization of the existing buildings into residential buildings, commercial buildings, and wattle and daub houses. Vulnerability functions for all three types of structures are adopted to assign level of vulnerability in building-scale when flood strikes.



(a) (b) (c)

Figure: a) Depth-damage curves for residential and commercial buildings (after Huizinga et al. 2017), b) Depth-damage curve for Wattle and daub houses (after Thapa et al. (2020), and c) Flood vulnerability map with depth raster for 100 yrs flood

A score-based vulnerability level and ultimately the buildings within the neighbourhood was calculated adopting the following scheme:

>=0.6	0.4-0.6	0.2-0.4	0.05-0.2	<0.05
Very high vulnerability	High vulnerability	Moderate vulnerability	Low vulnerability	Very low vulnerability

The results shows that 75% of the total flooded buildings fall under the very high-risk category of flood vulnerable.

Conclusions

The present study quantified the extent of flood hazard and level of vulnerability, which concludes that severity is persistent due to complex flood dynamics in the commercial district of Sauraha neighbourhood. The implication of this study can be further processed to design flood protection structures, meanwhile, detailed assessment covering sophisticated modeling and analysis in terms of hydrological, hydraulic, and structural aspects is a dire need.

Reference

Gautam, D., Dong, Y. (2018). Multi-hazard vulnerability of structures and lifelines due to the 2015 Gorkha earthquake and 2017 central Nepal flash flood. Journal of Building Engineering, 17, pp.196-201.

Huizinga, J., de Moel, H., Szewczyk, W. (2017). Global flood depth-damage functions: Methodology and the database with guidelines (No. JRC105688). Joint Research Centre (Seville site).

Thapa, S. et al. (2020). Catchment-scale flood hazard mapping and flood vulnerability analysis of residential buildings: The case of Khando River in eastern Nepal. Journal of Hydrology: Regional Studies, 30, p.100704.

FOR FURTHER INFORMATION:
Government of Nepal
Ministry of Energy, Water Resources and Irrigation
Water Resources Research and Development Centre
Dr. Ananta Man Singh Pradhan, Sr.Div. Engineering Geologist, ananta.pradhan@nepal.gov.np
Mahesh Khanal, Information Officer, mahesh.khanal@nepal.gov.np
Website: www.wrrdc.gov.np

Citation: Pradhan, A.M.S., Lamichhane, S., Paudel, H. (2021). Settlement-scale flood hazard mapping and vulnerability analysis of buildings. WRRDC Research Letter, Issue no: 10, July 2021, pp. 1-2.