Citizen Science Can Provide Valuable and Complementary Information in Water Resources Management: A Case Study of Urban Flood Assessment in Hanumante River Basin, Nepal

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1.0 Introduction

Citizen Science (CS) is the involvement of the non-scientists (i.e. students, the general public) to bring-in /understand new/existing scientific knowledge (Buytaert *et al.*, 2014). Recent technological developments in sensing technology and Information and Communication Technology (ICT), in particular, smartphones, are opening new techniques of data acquisition and dissemination (Hart and Martinez, 2006). Water resources management is significantly sustained by the availability of adequate hydrological data. Hydrology remains highly data-scarce; in many regions, if data exists, the lengths of data series are not sufficient. CS plays an important role in complementing information in the field of water resources management.

Kathmandu Valley, KV, (the capital city of Nepal) faces rapid urbanization. More than 60% of previously agricultural land is now haphazardly settled during recent 3 decades resulting in a concrete jungle. Since 2014, flooding due to pluvial, fluvial or combination has increased in urban rivers of the KV. An absence of hydro-meteorological data in such rivers is one of the major challenges in flood management. In July 2018, a high rainfall pocket was observed in the eastern region of Bhaktapur (one of the cities of KV). Hanumante River swelled up and flood happened like never before affecting the local population and transportation system as shown in **Fig. 1** (Prajapati *et al.*, 2018). Hanumante River is one of the major tributaries of the Bagmati River in the KV.

Fig. 1 Inundation scenario in Bhaktapur on July 2018. (Source: Prajapati *et al.*, 2018)

2.0 Materials and Methods

In the Hanumante River Basin (HRB), there are no hydrological stations and only 4 rainfall stations are available that are maintained by the government body responsible for hydro-meteorological monitoring. Smartphones For Water Nepal (S4W-Nepal), a non-profit organization, initiated a CS-based urban flood monitoring system in HRB) during the early monsoon of 2019. A network of 6 hydrological and 16 precipitation stations was established in the HRB (shown in **Fig. 2**), where citizen scientists recorded daily water level and precipitation measurements from July 2019. Water level measurement should be taken daily in the morning and in case of flooding, high flood level (HFL) should be noted. Similarly, in case of inundation, depth should be noted in nearby settlement. The selection of sites was done after the reconnaissance survey, and series of stakeholders' consultation (which involved local government representatives, and academicians).

Almost all citizen scientists are of age group 20-25 (undergraduate students or freshly graduated). All the water level and rainfall data are recorded in an Android smartphone application called Open Data Kit Collection (ODK collect) and are transmitted to the centralized database using either Wi-Fi or cellular communication. In addition, discharge measurements were conducted by the S4W-Nepal team members using a SonTek FlowTracker acoustic Doppler velocimeter with the United States Geological Survey (USGS) mid-section method two times a month.

Hourly satellite-based precipitation data from (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks - Cloud Classification System (PERSIANN-CCS), a spatial resolution of 4km, was used to capture intra-diurnal variation. Instead of using the absolute values of PERSIANN-CCS, this study used the daily precipitation values measured by citizen-scientists. We developed a kinematic wave flow model on hill slopes for simulating surface runoff and a two-dimensional (2D) shallow-water equation unsteady flow model to simulate the inundation process. Currently, we are collecting topographical data of the HRB. We believe these data could help develop a numerical model and understand the flood dynamics in the HRB.

3.0 Results and Discussions

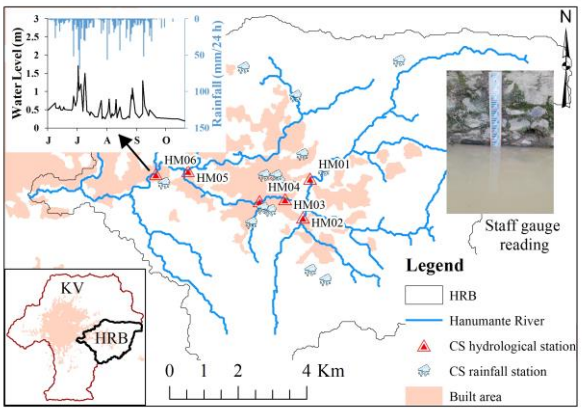

Fig. 2 Location of CS stations over the study area, sample staff gauge reading photo, and sample data at the outlet.

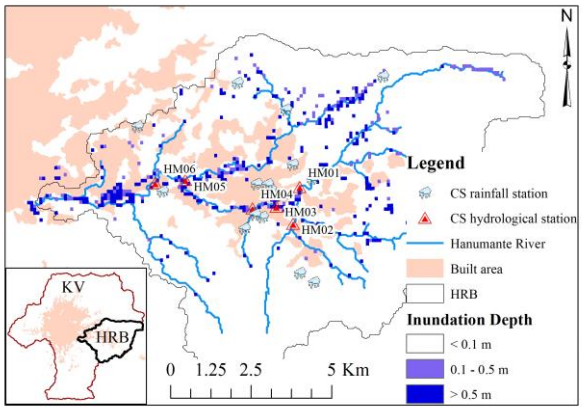

Fig. 3 Preliminary simulation result of inundation

Initial result of the simulation for maximum inundation during 2019 monsoon in HRB is shown in **Fig. 3**. The topography used is a coarse resolution of 90 m SRTM DEM and calibration of parameters is currently ongoing Flooding is not a new event but an inability to monitor has remained a persistent problem. The capacity of the government to install and operate new hydro-meteorological monitoring stations at the tributary level is constrained by many factors like human and economic resources. In this regard, to use the CS approach by involving local community people is one of the economic approaches.

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