Flood Damage Assessment and Inundation Mapping of Helmand River, Afghanistan

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1. Introduction

Afghanistan is highly prone to intense and recurring natural hazards, including earthquakes, floods, flash floods, landslides, avalanches, and droughts. Where 54% of the natural disasters in Afghanistan are water-related and makes the country the second most vulnerable country to floods worldwide[1]. The country is prone to river flooding which cause substantial destruction to crops, human lives, and properties. Helmand River Basin is the largest of the five river basins in Afghanistan. It is a closed basin, which covers the southern half of the country draining to the unique Sistan depression near the Afghan-Iranian Border (Fig. 1a). About 80% of the population of the basin depends on agriculture and livestock for their livelihood. The middle and lower parts of the basin supports extensive agriculture. Although floods affect almost every part of the basin with varying intensity and frequency, the middle and lower parts of the basin is regarded as one of the most flood vulnerable areas. Unfortunately, residents in the flood prone area are, meanwhile, not sufficiently aware of flooding consequences due to the inadequate information and lack of quality flood data. Thus, the flood prone area has been carelessly developed for settlement and cultivation purposes.

Floods in Afghanistan Rivers vary due to hydrologic regimes that fluctuate throughout the year. Some of the rivers, for example, have a pluvial regime, in which rain and snowmelt produce a late winter–spring maximum, and a late summer–early fall minimum due to not precipitation in this period[2]. Helmand River likewise experiences flood due to intense rainfall and rainfall coupled with rapid snowmelt. Where the intense rainfall-induced floods occur mainly in spring, which lies under the flash flood category. Such flash floods strike the flood prone area for a short duration, whereas the rain and snow-fed coupled floods last for a longer period.

2. Study area

The study focus on the flood prone area of Helmand River Basin (HRB), approximately 4402 km^2 that lies along the banks of Helmand River and Arghandab Tributary River. About 90% of the area lies along Helmand River banks with the approximately 97 km length starting from capital Lashkargah city up to Garamsir district just downstream of Darweshan gauging station and 13% along the bank of Arghandab tributary river with 37 km length up to the confluence point at Qala-e-Bust area as shown in Fig. 1c.

The average width of the river in Lashkargah station is 110 m and varies largely along the downstream part of the reach. The study area is a rural catchment, which is mainly characterized by agricultural land use with floodplain elevations difference of about 80 m. the annual rainfall over the area is 114 mm occurring during the winter-spring period (Dec–May). The amount of rainfall in the study area can be described as being little compared to the rainfall in the upstream part of the catchment. This area is the most important part of the basin in terms of concentration of population and economic activities, the agriculture predominates the economy of the region. Nearly all cultivable areas are used for double crops a year. The main winter crops are wheat and the summer crops are cotton, maize, beans.

3. Data and Methodology

Historical and recent flow data of three river stations (Lashkargah, Qala-eBust and Darwishan) are used to perform flood frequency analysis of the annual peak flow. Moreover, the historical data is used for making representative hydrographs in this catchment using the empirical method[3]. The topography and land use data are obtained by means of Remote Sensing and GIS

tools. As the digital surface model, we use the JAXA ALOSW3D30m DSM because this product provides better quality topography. With 'Supervised classification' tool of ArcGIS, Landsat 8 image acquired in 2019-April-27 is used to classify the land use for the area. The procedure for flood risk assessment of the area consisted of six steps: (a) flood frequency analysis based on historical and recent data, (b) preparation of geospatial data, (c) development of design flood hydrographs, (d) flood routing, (e) hazard classification and damage assessment, and (f) floodplain mapping and visualization.

4. Outcomes and Discussions

Land-use classes for agriculture and urban area in the study area are about 38% and 3 % respectively. The agricultural area tends to be affected by flooding compared to the urban areas. The flooding problem becomes severest to human lives due to the rural settlements where the mud floors houses are located in a distributed manner in each cultivated farm of the agricultural land. The inundation depth, flow velocity, and inundation duration are considered as parameters for damage assessment.

The study found that the flood plain tilting downward to east direction has a large influence on the flood depth distribution. In Helmand River, the highest depth and velocity tend to the left bank side. While the Arghandab tributary river is comparatively uniform in terms of flood depth and velocity as shown in Fig.2 because the flood plain in this tributary is not tilted.

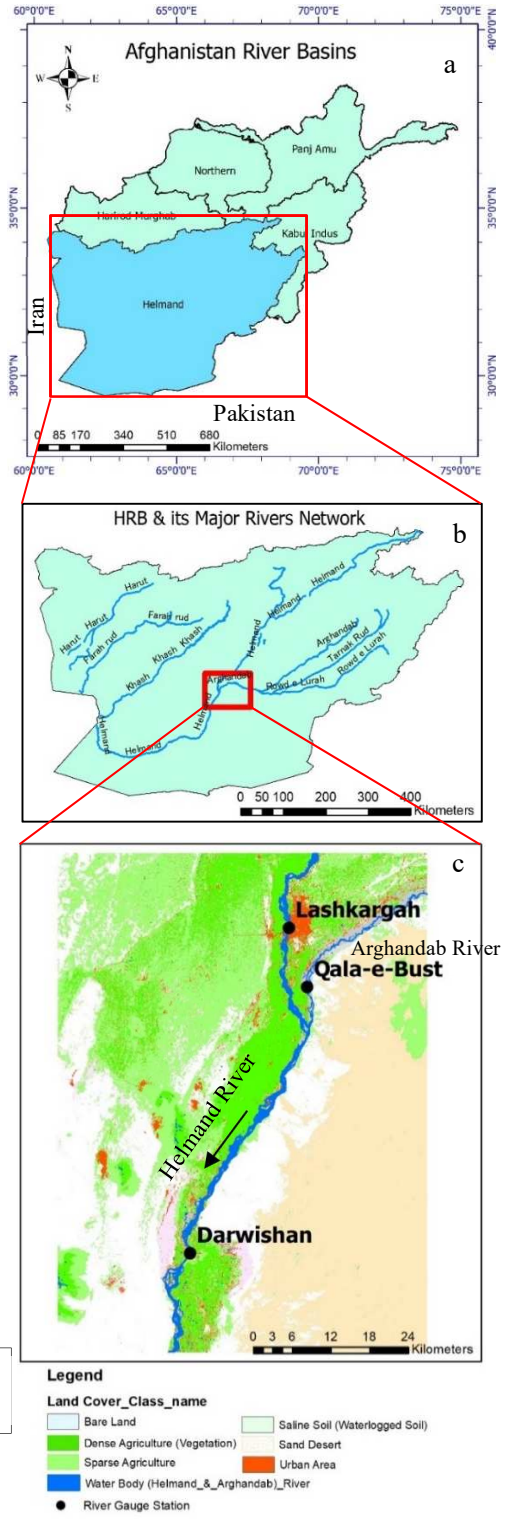

Fig.1 Study Area and Land Use.

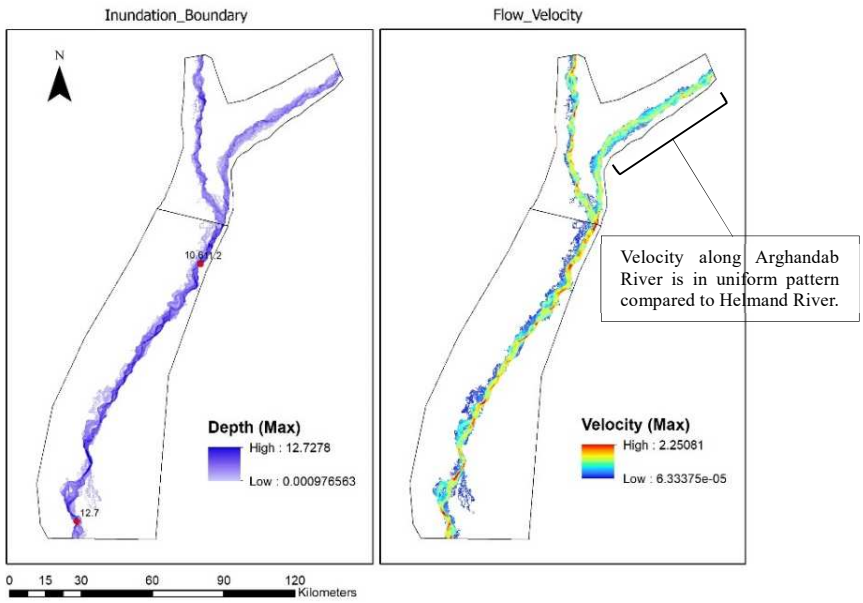

Fig.2 Flood water depth and velocity for 10-Year flood.

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3) Beni P. Sangal: Practical method of estimating peak flow. J. Hydraul. Eng., 109(4), 549–563, 1983.