

SHORT COMMUNICATION

Mapping Flood Risk Assessment by Remote Sensing in District Chiniot, Pakistan

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Introduction

A flood is a catastrophic event of natural origin which involves exposure of human population, infrastructure, and resources. Heavy rainfall in river catchments, snow melting in monsoon season, inadequate drainage networks, water overflowing from the main drainage channels, conversion of natural vegetation, agricultural land, and wetlands due to urbanization are the core reasons of floods. Whereas, climate change has made the condition worse and increases the frequency of the floods. Asia consists approximately one-fifth of the earth's land area with half of the world's population living in this continent. As natural disasters increased around the world, Asian countries also continued to experience hazard events especially from 1994 to 2004, when nearly 60,000 people were killed in floods (Arambepola, 2009).

Summer floods have been common in almost all the South Asian countries in the last few decades especially in Pakistan; it has been recognized as a major calamity (Ahmad et al., 2011). Floods are one of the most common natural disasters, which cause loss of economics lives and in Pakistan, floods are generally caused by heavy rainfall, which is sometimes combined with snowmelt and produce high flood in major rivers of the country. Since 1947 Pakistan has faced 22 flood events which caused a cumulative loss of more than US\$38.00 billion (Federal Flood Commission Pakistan, 2014). The flood in September 2014 is considered worst proper which affected more than 2.5 million people and resulted in loss of 129,880 houses and 1.0 million acres of cropland (Rehman et al., 2016-2017).

The present study area focuses on district Chiniot of Central Punjab (Figure 1). The river Chenab flows through the east of study area, igneous and metamorphic rocks of Kirana hills (Ahmad et al., 2016). The major outcrops of Kirana hills are spread over larger area beyond district Chiniot near Sargodha, Shahkot and Sangla Hills (Shah, 2009; Khan et al., 2017). These hills at some places prevent some areas of this district from floods. River Chenab originates from Himachal Pradesh in India and enters Pakistan near Marala about 480 km from its origin. On the way to Chenab bridge, it flows through

Marala, Khanki and Qadiarabad headworks and then meets with Jhelum river at Trimmu barrage in downstream (Hanif et al., 2016) (Fig. 2).

In the study area, Chenab river overflows and causes damage to property during floods. As district Chiniot has badly affected by floods in the past, therefore it would be useful to create a risk map of the district. In this paper satellite imageries of flood events and computed affected area were used. This study can be used for flood warning system and planning departments.

Materials and Methods

For this study, the maximum flood peaks data of Marala, Khanki, and Qadirabad headworks of Chenab river (1973- 2016) were obtained to estimate river overflows in the past. GIS techniques were used to map the extent of historical floods in Chiniot district by acquiring historical satellite imageries of Chenab river and then flood hazard maps of the study area by using ISO Clustering Unsupervised Classification technique in ArcGIS 10.5 to assess the overflow of Chenab river during floods (Uddin et al., 2013). The river overflows were identified on historic satellite and correlated with recorded flood flow on upstream heads.

Results and Discussion

Federal Flood Commission, Islamabad (Annual Flood Report, 2006) has classified flood level of 250,000–300,000 cubic feet per second (cfs) as a low flood (L-F), 300,000–450,000 cubic feet per second as a medium flood (M-F), 450,000–650,000 cfs as a high flood (H-F) 450, 650,000–800,000 cfs as a very high flood(V-H-F), and more than 800,000 cfs as an extremely very high flood(E-V-H-F (Khan et al., 2011). Historic floods of the Chenab river have been categorized based on the above-mentioned classification on different headworks (Table 1).

Figure 3 shows the historic satellite imageries of previous floods. The dark blue colour shows the actual extent of river water, green patches showing the vegetation while another light blue shade indicates the overflowing of water from river banks (Fig. 4).



Fig. 1 Location map of the study area. Encircled part is district Chiniot.

The analysis of pre and post-flood Landsat 8 images classification of 2014 shows the extent of flooding in the central part of Chiniot district which causes the destruction of agricultural fields, livestock, schools and

residential areas (Fig. 4).

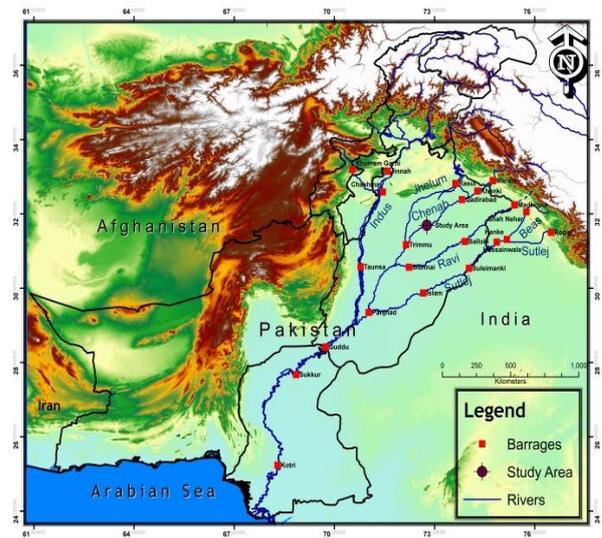


Fig. 2 Map showing river system of Pakistan and various headworks where river flow is measured.

The central part of the district has a bridge over the River Chenab close to the city Chiniot. The bridge is

Table 1 Maximum flood peak discharge data at headworks from the year 1973-2016.

YEAR	MARALA			KHANKI			Q.ABAD		
	Date	Discharge In Cusecs	Flood Level	Date	Discharge In Cusecs	Flood Level	Date	Discharge In Cusecs	Flood Level
1973	9 Aug	769650	V-H-F	10 Aug	1000496	E-V-H-F	10 Aug	854341	E-V-H-F
1975	16 July	582600	H-F	16 July	666241	V-H-F	17 July	669819	V-H-F
1976	2 Aug	549400	H-F	2 Aug	615043	H-F	2 Aug	628741	H-F
1988	25 Sep	750975	V-H-F	26 Sep	864220	E-V-H-F	26 Sep	878719	E-V-H-F
1992	10 Sep	845090	E-V-H-F	10 Sep	910512	E-V-H-F	11 Sep	948530	E-V-H-F
2014	6 Sep	861464	E-V-H-F	7 Sep	947099	E-V-H-F	7 Sep	904285	E-V-H-F

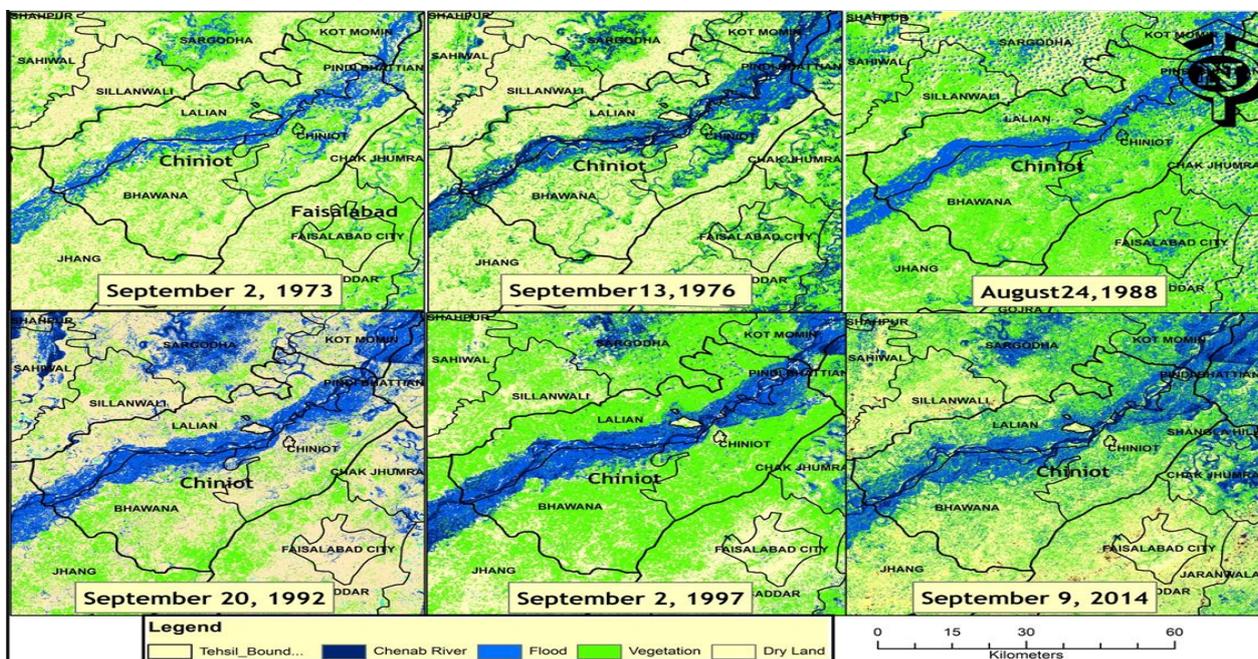


Fig. 3 Historical flood satellite imageries of District Chiniot from 1973 to 2014.

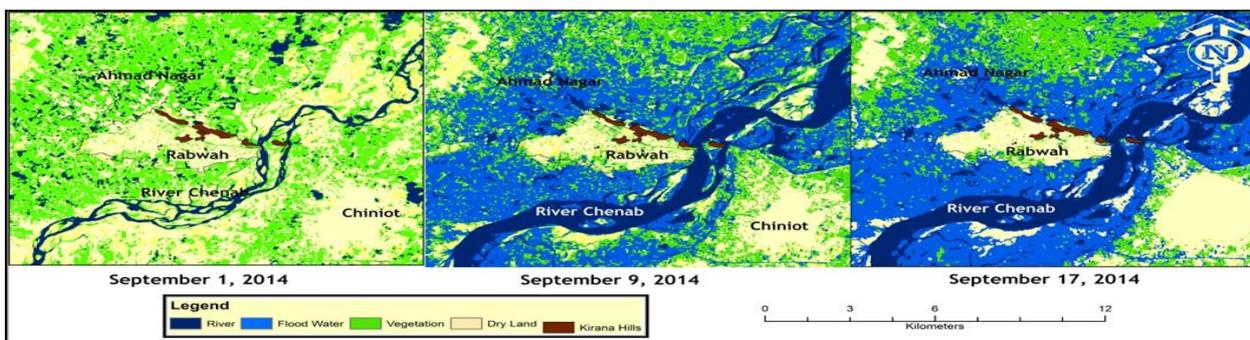


Fig. 4 Pre and post-flood images of 2014 flood event in the central part of the Chiniot in the vicinity of the Chenab river.

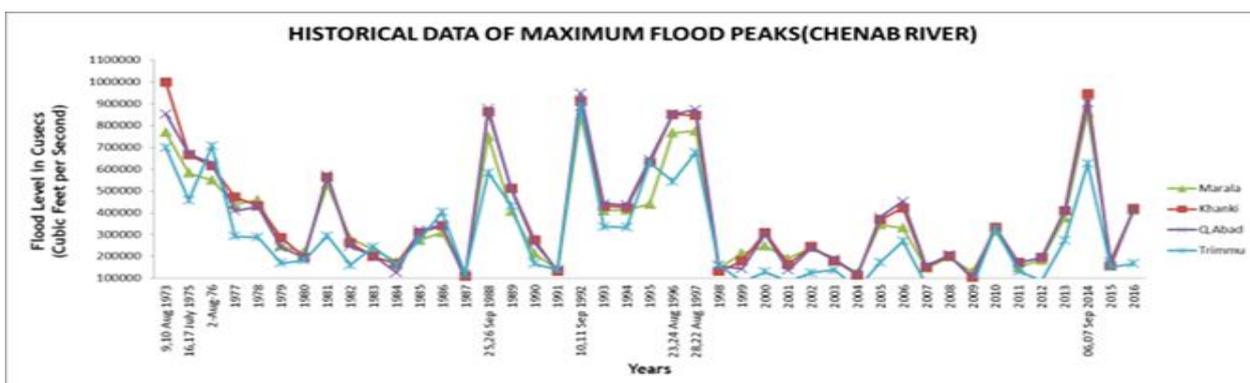


Fig. 5 Maximum historical flood peaks of Chenab river.

on the main highway connecting two main cities, Faisalabad and Sargodha. It is critical to keep this main highway open and it is important to issue an early flood warning necessary for hazard preparedness.

In 2014, there was a high flood in the river Chenab which caused the water discharge of 861464 cusecs at Marala, 947099 cusecs at Khanki, 904285 cusecs at Qadirabad Barrage and 842500 cusecs at Chenab

Table 2 Historic flood record of Chiniot district.

Year	Flood peak	The gap between flood peak and imagery (days)	% of the affected area
1992	948530 (Sep 11)	9	26%
1993	443054 (July 11)	10	22%
1995	644697 (July 29)	14	13%
1996	853231 (Aug 24)	6	26%
1997	873442 (Aug 28)	5	27%
2014	904285 (Sep 07)	2	39%

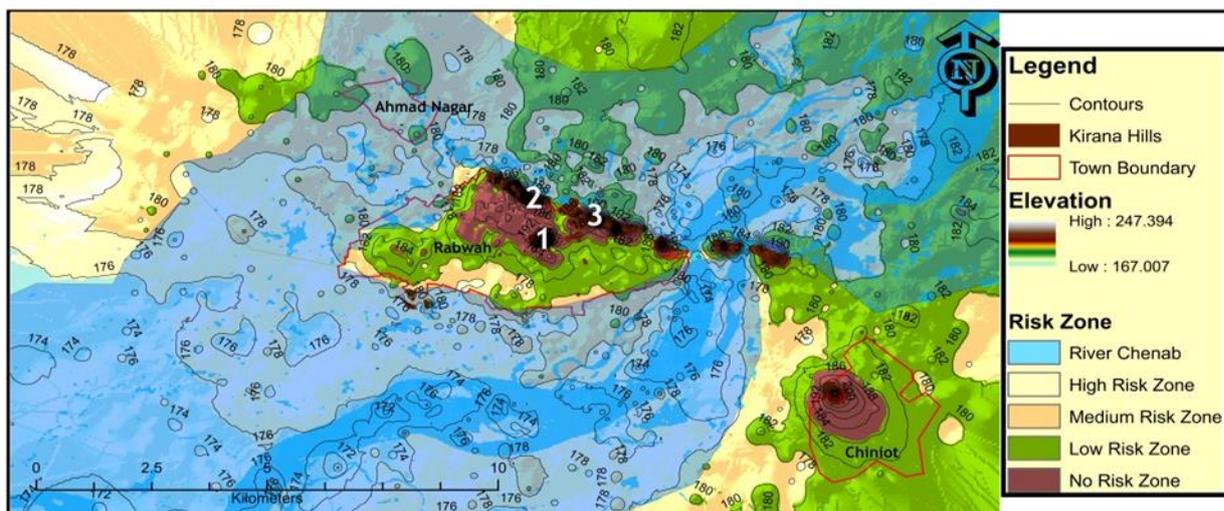


Fig. 7 Marked flood risk zones based on height contours. Light blue colour indicates overflow of the River Chenab in 2014 flood.

Bridge (Chiniot). The maximum peak was observed on September 07 at Qaidarabad (Fig. 5). The analysis of satellite images of 2014 (Fig. 6) indicates that on September 9 the Chenab river was overflowed in the vicinity of Chiniot city and Rabwah town and river water overflow to the main highway connecting Faisalabad and Sargodha near Ahmad Nagar town. The overflow water can be seen until September 17, 2014. According to flood routing map issued by the meteorological department, water from Qaidarabad head takes 30 hours to reach Chenab bridge at Chiniot. Therefore, based on previous flooding events and remote sensing early warning system can be issued for areas, which are under threat.

Figure 7 shows height contours and overflow of the Chenab river in the surrounding of Chenab bridge close to the Chiniot city. The old centre Chiniot city and Rabwah town never touched by floodwater due to high elevation (Fig. 7). The high elevations are along exposed Pre-Cambrian Rocks of Kirana hills. The north of Rabwah town is safe as it is covered by Kirana hills. The height varies from 170 to 242 meters. The highest elevation contour is at the top of the hill (marked by white color numbers 1, 2, 3 in Fig. 7). As per the analysis of remote sensing of flood in 2014, (842500 cusecs) most of the areas lower than 180 meters mean sea level height were flooded with water in the vicinity of Chiniot city and Rabwah town. Thus, the previous flood remote sensing data can provide useful information for flood disaster management. According to historical flood data, the average frequency of 8000,000 cusecs flood is once in a decade (Fig. 5).

The calculation of flood satellite imagery shows that almost 26% area of District Chiniot was affected in 1992 by flood. Whereas, 26% area in 1996, 27% in 1997 and 39% areas of the study area were affected in 2014 floods (Table 2). The water level was noted more than 800,000 cfs meaning this amount can be considered a sign of danger in flooding seasons. However, 443054 cfs water passed through the area in 1993 but it also flooded the western parts of the city at that time and inundated around 22% area.

Conclusion

The study has described the integration of GIS and Landsat imagery in delineating flood hazard extent of the Chiniot district. The results provide essential information for planners and administrators to manage flood hazards and formulate a remedial strategy.

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