Geo Spatial Assessment of Flood Hazard in Jhang District, Pakistan

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Abstract: Floods are one of the leading natural disasters in Pakistan. In recent decades the frequency and intensity of floods has increased due to human and environmental factors. In this work an attempt was made to examine the flood vulnerable areas of Jhang district and its impact on land cover changes by using remote sensing and GIS techniques. Image Analysis and different indices like NDVI, NDWI were applied on satellite images for identification of flood prone areas and vegetation conditions in study area. Flood prone areas were further classified into low, medium and high risk areas according to flood hazard. The results indicate that, Jhang covers total area of 6357 km^2 out of which flood affected area is 530 km^2. During the flood of 2010 water area expanded approximately 714 km^2 while a decline was observed in agricultural lands which have lost139 km^2 area under vegetation.

Keywords: Flood Hazard, Vegetation Cover, Image Analysis, NDVI, Jhang.

1. INTRODUCTION

Climate change is increasing worldwide at an alarming rate in recent decades. Internal and external forcing mechanisms, population explosion, urban expansion and anthropogenic activities are responsible to alter the composition of global atmosphere and cause climate change [1]. Changing pattern of precipitation, heavy rainfall, frequent floods, hurricanes, heat waves, wildfires and droughts are the most visible consequences of climate change [2]. Among the climatic change extreme events, hydrologic events (flood and drought) are the leading natural disaster worldwide which increased the intensity of destruction in terms of causalities, threat to life & property and economic loss [3]. Due to rapid pace of urbanization, industrialization, anthropogenic activities and climate change, flood hazard has been intensified and made the issue more prominent for vulnerability assessment, sustainable planning and development [4].

Floods have been the most catastrophic and widespread disasters causing causalities, devastation, economic loss, damage to infrastructure and property, loss of agricultural production and human lives [5]. Asia is the most populated region of the earth surface which suffers frequent and intense floods throughout the history. It is estimated that one third floods of world occurred in Asia that killed 60,000 people during the years 1994 - 2004 [6]. From the last few decades, many countries of Asia including Pakistan confronted frequent and excessive floods due to heavy precipitation in summer monsoons, land cover changes with impervious surfaces, improper and poor management of drainage systems which cause a reason of nearly 50% of flood-related casualties in the last century [7-9].

Pakistan is considered as highly flood prone region which was affected by floods of different magnitude almost every year since 1947. Pakistan received serious floods in Indus River and its tributaries and shows a long history of floods while the floods of 2010 and 2011 are the most destructive [8]. The multi-spectral and multi-temporal remotely sensed data incorporated with techniques of geo informatics provide adequate information and make it possible and convenient for the mapping of flood hazard, changes in river channel, damage of infrastructure and agricultural productivity [10]. The aim of present work is to map flood affected area, analyze the conditions of vegetation before and after flood in the study area and zoning of flood hazard using RS & GIS techniques.

2. STUDY AREA

This study is conducted in Jhang district, which is almost located in the central Punjab. Jhang is located at 31° 18' 24.37" North and 72° 19' 41.3" East. Sargodha and Chiniot districts bound it in the North while Khanewal and Muzaffargarh in the South. Bhakar and Layyah districts lie in the West while Faisalabad

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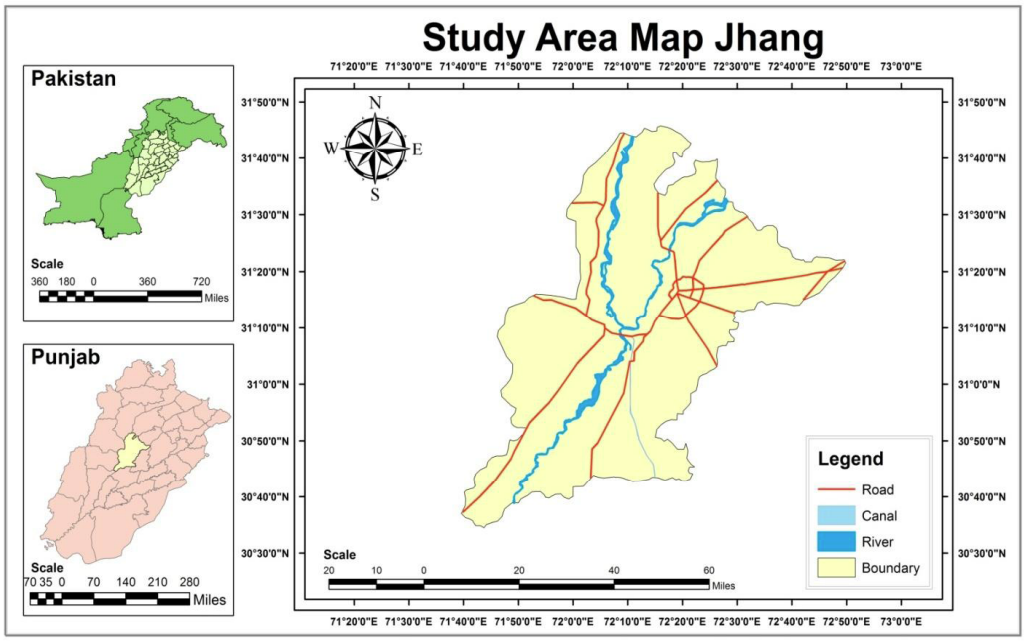


Figure 1: Location Map of Study Area.

and Toba Tek Singh make the eastern boundary. It is 9th largest city of the Punjab with an average elevation of 155 meters above sea level. According to 1998 Census Report total population of district Jhang was 2.8 million with population density of 322 persons/square kilometers. The latest studies show that the population of Jhang has increased about 3.5 million [11]. Jhang has arid type of climate and receives 241 millimeters annual rainfall. There is a big difference between summer and winter rainfall, most of the rainfall is received in July and August due to monsoon spell. Wind storms are blown frequently in summer season, particularly intense sand storms are observed in Thal desert. Total area of Jhang District is 6357 km^2 which is divided into four administrative units or Tehsils, namely Ahmed Pur Sial, Atahara Hazarai, Jhang Saddar and Shor Kot [12].

3. MATERIAL AND METHODS

The methodology adopted in present study is divided into following stages.

- Data collection
- Image Analysis

3.1. Data Collection

In order to examine flood vulnerability and conditions of vegetation cover before & after flood in Jhang, two Landsat images (pre and post flood) of 2010 (Path & Row 150- 38/39) were achieved from United States Geological Survey (USGS) with the resolution of 15 meters/pixel

3.2. Image Analysis

Before image processing ERDAS Imagine was used for Image preprocessing (layer stack, Geo referencing, mosaic, sub setting of study area) to make satellite images useable for further analysis. Pixel base classification is based on spatial and spectral values which show accurate results. In current study pixel base supervised classification with maximum likelihood classifier was applied to pre and post flood images to examine the land use changes in flood region.

After the classification process, images were converted from raster to polygons on the bases of their classes and extract water class from converted polygons through a query “Class Water”. This process was applied to both post and pre flood images for the estimation of flood extended area. To analyze the condition of vegetation before and after the flood NDVI (Normalized Difference Vegetation Index), in ArcGIS is calculated by raster calculator using following formula $NDVI = \frac{(NIR - Red)}{(NIR + Red)}$. Flow diagram of image analysis for the present study is presented in Figure **2**.

4. RESULTS & DISCUSSION

The findings of satellite images and results are shown in Table **1**. It reveals that the total area of all land use classes of study area was 6357 km^2. In Jhang

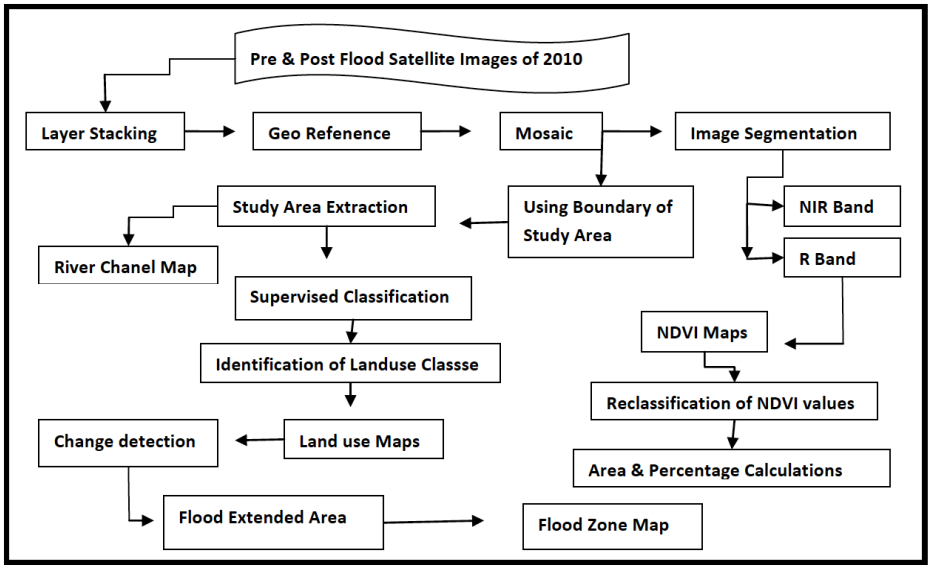
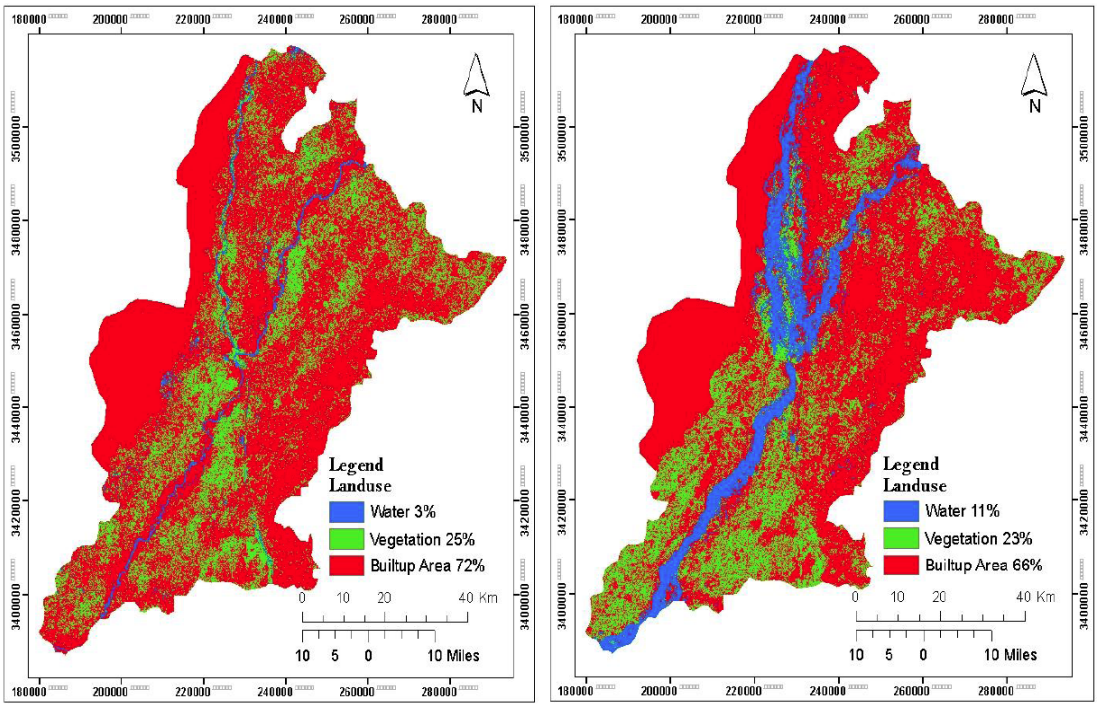


Figure 2: Flow Diagram of Image Analysis.

Table 1: Land use Changes in Jhang (Pre & Post Flood 2010)

Land use Change Detection					
Class Name	**Pre Flood Area (km^2)**	**Post Flood Area (km^2)**	**Change Area (km^2)**	**Pre Flood Percentage**	**Post Flood Percentage**
Water Bodies	183	714	531	3%	11.2%
Agriculture	1572	1433	139	25%	22.5%
Built-up land	4602	4210	392	72%	66.3%
Total	6357	6357		100%	100%



a **b**

Figure 3: (**a**) Pre Flood Land use. (**b**) Post Flood Land use.

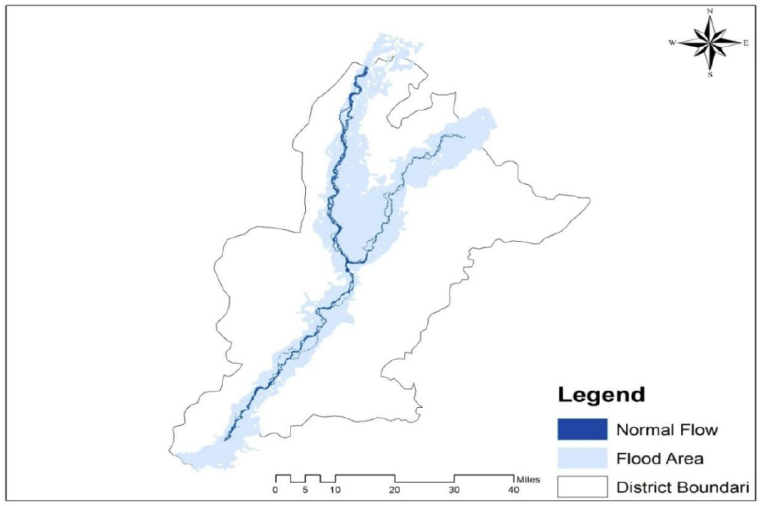
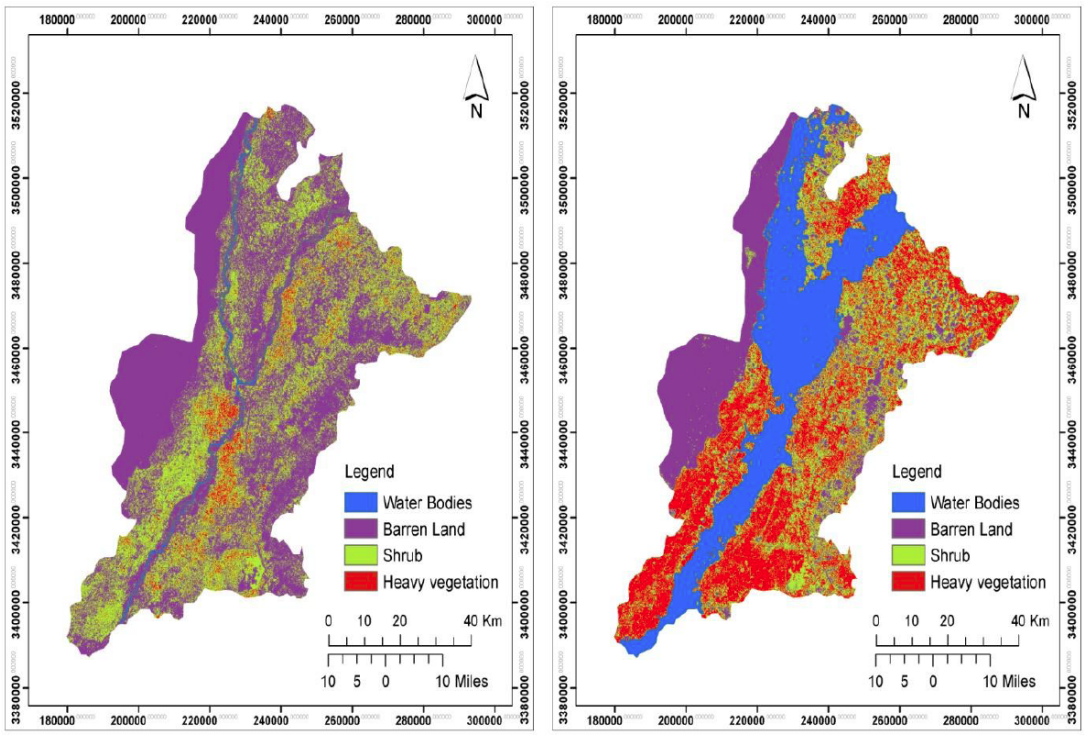


Figure 4: Flood Prone Area of 2010.

Table 2: Vegetation Conditions in Jhang

Normalization Difference Vegetation Index				
Class Name	**Pre Flood Area (km^2)**	**Pre Flood Area (%)**	**Post Flood Area (km^2)**	**Post Flood Area (%)**
Barren Land	3908	61.4	1868	29.4
Shrubs	2010	31.6	1982	31.2
Healthy Vegetation	256	4	1793	28.2
Water	183	3	714	11.2
Total	6357	100	6357	100



a **b**

Figure 5: (**a**) NDVI Map before Flood. (**b**) NDVI Map after Flood.

district, Chenab and Jhelum rivers covered the area of 183 km^2 during normal flow in 2010 but in month of August 2010, due to excessive monsoon rainfall in the region, water covered area increased dramatically which spread over the area of 714 km^2. It is found that intense flooding in the study area changed the patterns of land use. Figures **3** & **4** reveals land use changes that occurred before and after flood and flood prone area respectively.

To examine the vegetation conditions of Jhang NDVI maps are shown in Figure **5**. Pre & Post flood NDVI values were 0.52_ - 0.22 and 0.61_- 0.97 respectively. According to USGS major types of vegetation cover in study area are water and barren land, shrubs and heavy vegetation. From the results it is observed that smallest NDVI values were recorded in water bodies and barren land while highest NDVI values were estimated in non-urban (vegetated/rural) areas.

It was also found that due to excessive rainfall in the region the extent and magnitude of water bodies increased drastically and notable loss of agricultural lands is recorded. In terms of vegetation type, barren land shows a decline while heavy vegetation shows a boosting trend due to heavy rainfall in study area. Figure **6** presents the normal and high risk zones of flooding in the district. This map can be helpful for urban planners for future development in order to minimize the effects of floods in the area.

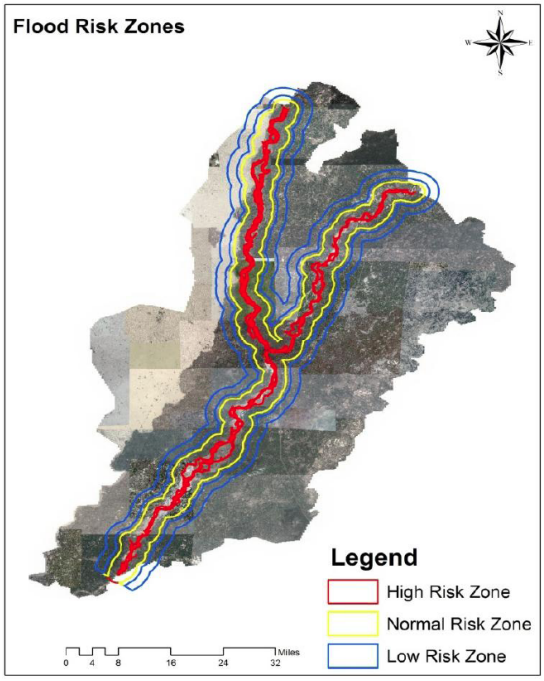


Figure 6: Flood Risk Map of Jhang.

5. CONCLUSION

Flooding is the natural, catastrophic and periodically phenomenon in Jhang which have caused significant economic loss in the past. The intention of current study is the identification of the major flood affected areas and to evaluate the pre and post dynamics of land use and vegetation conditions in Jhang which is considered as flood prone area of Punjab. The results of the study revealed that heavy monsoon rainfall in August 2010 caused flood in study area which extent over the area of nearly 714 km^2. It is also concluded from the above study that GIS and remote sensing techniques are found very effective tools for flood hazard mapping and its impacts on land use changes.

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