ESTIMATING FLOOD – 2010-11 EXTENT USING SATELLITE REMOTE SENSING DATA IN PAKISTAN

By

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Abstract

Heavy rains in 2010 triggered both flash floods and riverine floods in several parts of the country resulting in a loss of life and widespread displacement. Khyber Pakhtunkhwa (KPK), Baluchistan, and Punjab have been the worst hit. Thousands lost their homes and livelihoods. Crops have been destroyed, and communication network such as roads and bridges destroyed. In KPK, these are the worst floods since 1929 and 25 districts have been reported badly hit. At least 400,000 people were affected. Swat, Charsadda, D. I. Khan, Tank and Upper and Lower Dir districts were among the districts badly damaged. They have received between 100 – 290 mm of rain. This is the highest recorded rainfall in the region in the past 35 years. In 2011 monsoon also resulted heavy downpour. The major thrust of rainfall was in Sindh province where cumulative rainfall varied from 400 mm to around 1000 mm. The maximum rainfall during the period was from 1-July 2011 to 28-September 2011. The rainfall of the order of 1044 mm was observed in Mithi, Sindh.

Remote Sensing (RS) is a technique employed for identification of earth surface features using electromagnetic radiation as a means of interaction. A careful assessment of changes that occur in earth's environment forms a major milestone for effective disaster management. All these can be undertaken through the collection of accurate, reliable and comprehensive set of scientific data. Satellite Remote sensing (RS) data, with its ability for a synoptic view, repetitive coverage to detect changes, provide a better option as compared to traditional methods when it comes to disaster studies. Earth Observation (EO) capability of mankind has increased manifold since the launch of first remote sensing satellites. Spatial, Spectral, temporal and radiometric resolutions improvement is a continuous process. Improvements have also been observed in their coverage and value-added products. Earth observation satellites have contributed significantly in particular in all disaster management areas: disaster mitigation, disaster preparedness, disaster relief and also disaster rehabilitation. In this paper, flood extent was calculated and crop damage was also assessed using MODIS sensors 250m resolution satellite data on daily basis during 2010 and 2011 floods in Pakistan.

Introduction

Heavy rains in 2010 triggered both flash floods and riverine floods in several parts of the country resulting in a loss of life and widespread displacement. Khyber Pakhtunkhwa (KPK), Baluchistan, and Punjab were the worst affected. People in thousands lost their homes and livelihoods. A large part of communication network such as roads and bridges damaged besides colossal loss to crops. All 7 districts of FATA were affected, according to the FATA Disaster Management Authority. This was the worst flood in KPK since 1929. At least 400,000 people have been affected. Swat, Charsadda, D. I. Khan, Tank and Upper and Lower Dir districts received between 100 –290 mm of rain in a span of 24 hours. This is the highest recorded rainfall in the region in the past 35 years. Reports indicate that in Charsadda, more than 5,000 homes are underwater and 20 villages were affected. In Mansehra some villages were swept by landslides. In Baluchistan, floods hit seven districts including Sibi, Kohlu and Barkhan. It was reported that some 150,000 people have been affected. In Punjab the rains hit parts of upper Punjab; Mianwali, Attock, Rawalpindi and Jhelum.

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Heavy monsoon rains were also recorded during 2011. In Punjab, the highest rainfall of the order of 438 mm was received in Lahore. About 14 stations in Punjab received rainfall higher than 200 mm, 08 stations more than 300 mm and 3 stations more than 400 mm rainfall resulting in another flood in eight districts of Sindh province i.e. Dadu, Matiari, Hyderabad, Tharparkar, Nausharo Feroze, Khairpur, Jacobabad and Jamshoro, and three districts in Balochistan i.e. Jhal Magsi, Nasirabad and Jaffarabad and three districts of Punjab i.e. Vehri, Kasur and Bahawalnager.

In 2010, the floods began in an upstream catchment area of the Indus river system that does not have a warning system and has not been well studied, making it very difficult to monitor.

To remedy this lack of information, the new forecasting system combine with data sourced from satellites and ultrasonic radars as well as measurements from the sparse network of gauges on the ground would be needed to calculate the risk of flooding. Processing takes several hours, and the analysis can be updated on an hourly basis. These days satellite remote sensing data are extensively used in environment, agriculture, snow and glacier, coastal and marine resources, forestry, water resources, land use, urban sprawl, geology, natural and anthropogenic hazards monitoring, infrastructure development etc. Earth observation satellites have contributed significantly in all disaster management areas: disaster mitigation, disaster preparedness, disaster relief and also disaster rehabilitation.

Satellite Image Sources

As one of the most important data sources, the “International Charter – Space and Disasters” intends to promote cooperation among its members i.e. space agencies and industries in the use of disaster related satellite data (Stryker and Jones, 2009). In case of natural calamity UN Charter can be activated and satellite images of interest can be obtained in near real time. It facilitates the provision of relevant data to the affected countries or regions to enable them to effectively manage the rescue, relief and rehabilitation efforts during and after disasters. In this paper, flood extent was calculated and crop damage was also assessed using MODIS sensors 250m resolution satellite data on daily basis during 2010 and 2011 floods in Pakistan.

Data Processing

The UN Charter provided images are often geo-referenced by the data providers. However, such geo-reference may not be precise enough when they are overlaid with other reference data, such as road maps and high resolution images. Therefore, it is necessary to carefully evaluate the input images with reference to other data sources to ensure their correct geographic reference. Flood extent was determined through automated image classification, Object based image classification technique was used (Benz et al, 2004) and performed the following steps using ENVI, ArcGIS software: image segmentation and classification. This process is repeated for both the during-flood images and the pre-flood images. Additional information such as field surveys were used to find out the flood extent. The removal of normal water from the during-flood images gave the flood extent.

Results

Based on MODIS daily images, flood progression and extents were calculated (Ref. Fig.1 & Table.1). Maximum area under floods of around 70, 000 sq km was recorded on 23rd Sept.2010 in the country. In the south, the Indus river was in full flood. A dam breach upstream caused the waters of the Indus to diverge in August. While water remained in the main river channel and flowed toward the Arabian Sea, some water flooded agricultural lands and settlements to the west, ultimately pouring into Manchhar Lake. Flooding ravaged several settlements, including Mehar. Floodwaters also breached embankments and inundated the town of Johi and the nearby city of Dadu. As per UN World Food program in 2010 floods over 20 million people were affected all over the country with over 1500 deaths and 1.2 million houses damaged. (Fig.-2)

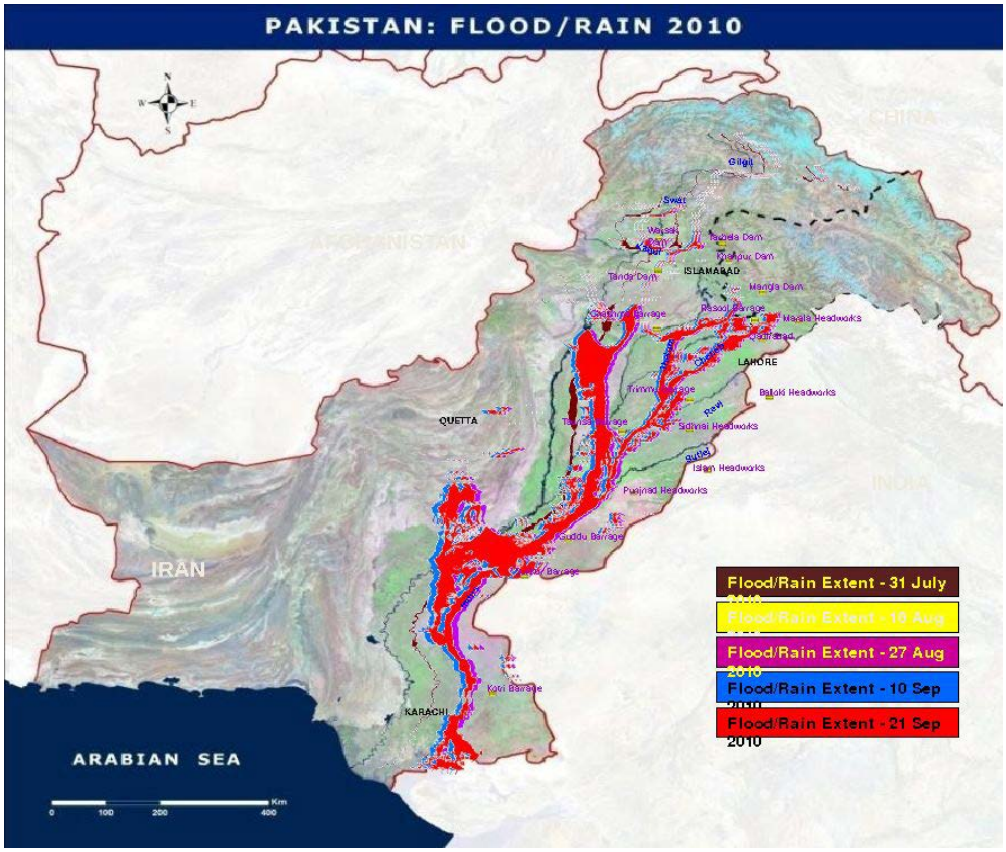
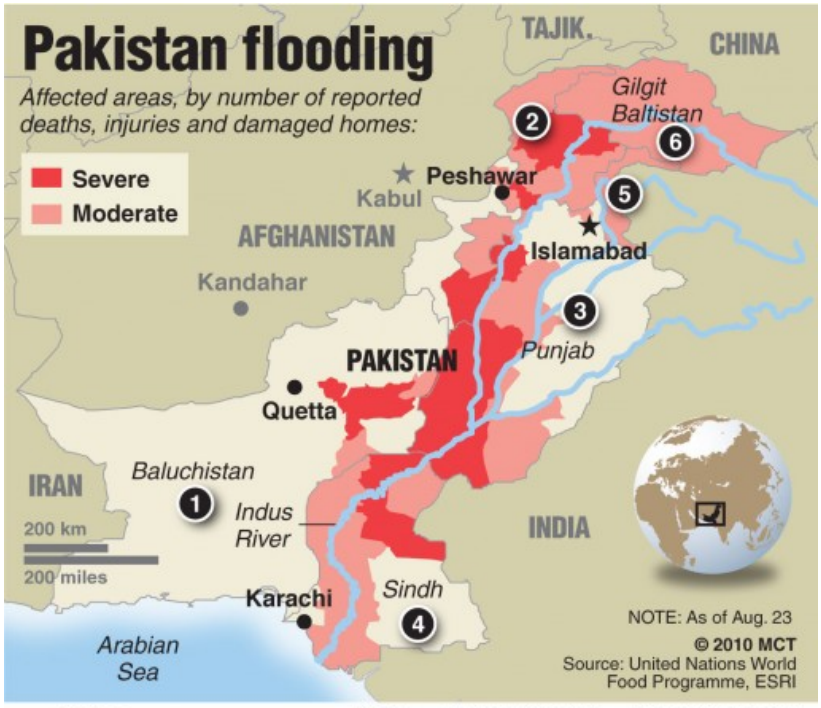


Figure-1 The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured these images of Pakistan during 2010 floods. Daily extent of floods was calculated using computer software. Source : SUPARCO

Table 1: Area under inundation during 2010 floods

Source: SUPARCO

Date	Area Sq/km
13-08-2010	59959
16-9-2010	61108
25-08-10	62417
27-08-10	64354
23-9-2010	70238



	Province	Deaths	Houses damaged	Population affected
1	Baluchistan	45	75,261	672,171
2	Kyber Pakhtunkhwa	1,068	179,874	4,365,909
3	Punjab	103	500,000	8,200,000
4	Sindh	71	462,251	3,684,267
5	Azad Jammu and Kashmir	69	6,472	245,000
6	Gilgit Baltistan	183	2,820	8,561
	Total	**1,539**	**1,226,678**	**17,175,908**

Figure 2-According to United Nations World Food Program data the 2010 floods directly affected about 20 million people, mostly by destruction of property, livelihood and infrastructure, with a death toll of close to 2,000.

In 2011 the southern province of Sindh was affected most by monsoon resulting in equal damages. Based on MODIS daily images, flood progression and extents were calculated (Ref. Table.2). Maximum area under floods of around 21000 sq km was recorded on 15th Sept.2011 in the province.

Table 2: Area under inundation during 2011 floods in the south (Sindh)

Source: SUPARCO

Date	Area Sq/km
20-8-2011	2912
04-09-2011	11774
15-09-2011	21201

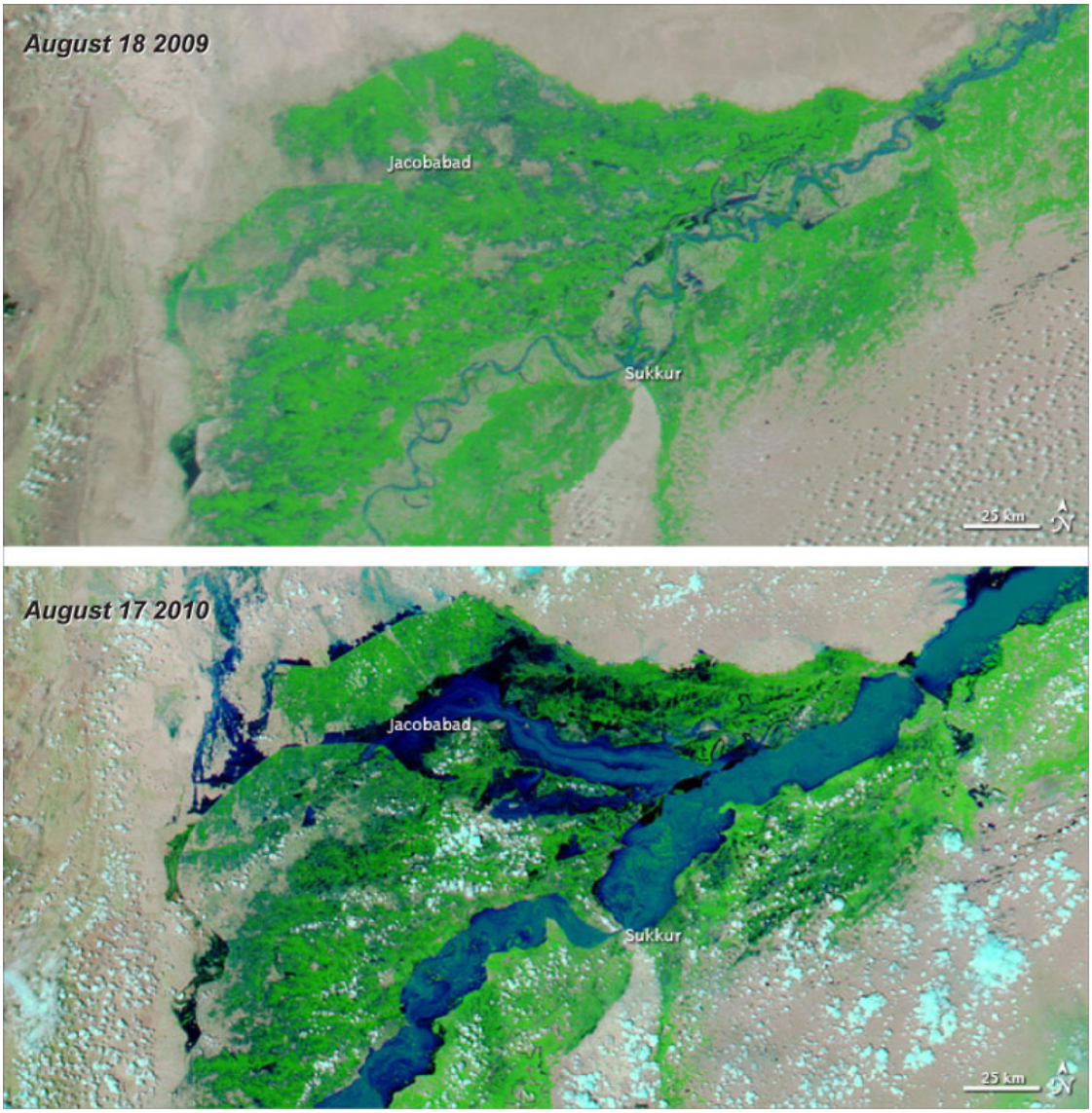


Figure 3-Top image acquired August 18, 2009, bottom image acquired August 17, 2010. The Indus River at Sukkur was at exceptionally high levels on August 17, 2010, when the Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite captured the top false-color image. The lower image shows the Sukkur region on August 17, 2010. Water ranges from dark blue to silvery blue, and plant-covered land is red in the false-color image. The dark blue canals surround the white-gray city of Sukkur in both images. In the bottom image, the Indus River extends over its banks across many kilometers.

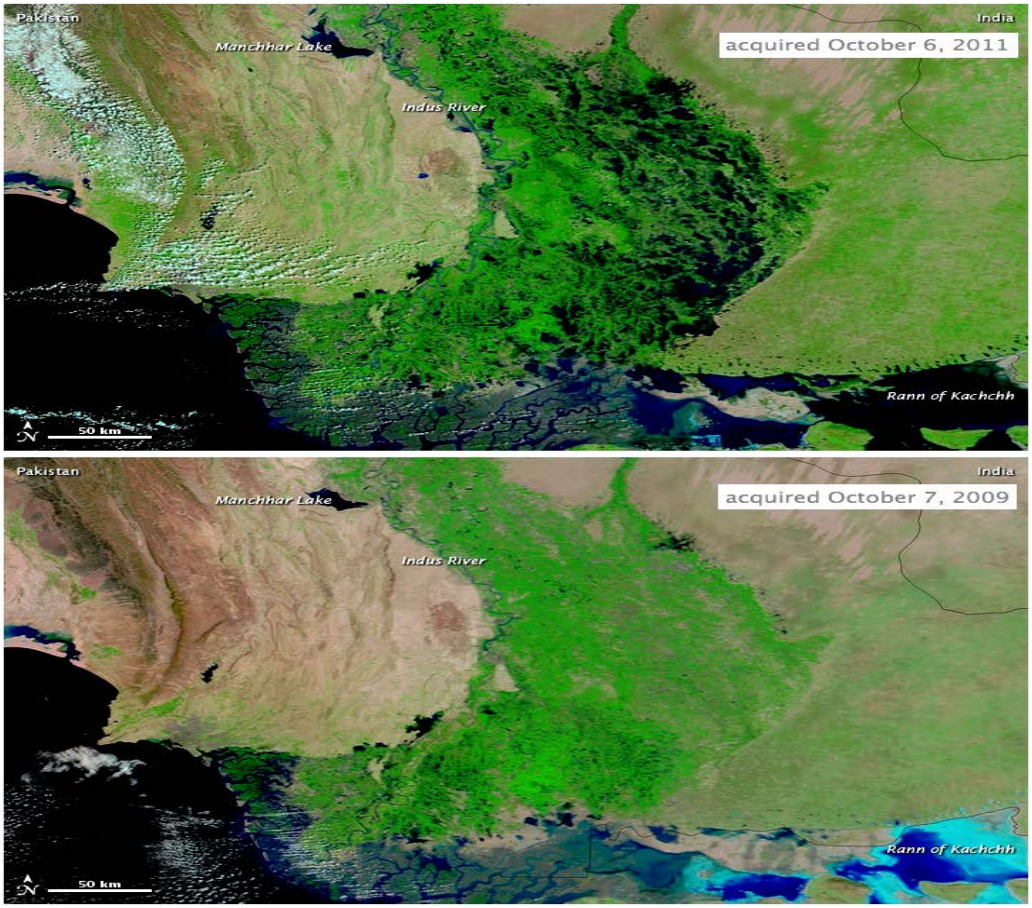


Figure 4-The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured these images of southern Pakistan on October 6, 2011 (top), and October 7, 2009 (bottom). Both images use a combination of visible and infrared light to better distinguish between water and land. Water ranges from electric blue to navy. Vegetation is green. Bare ground is pink-beige. Clouds are pale blue-green.

In 2009, most of the land east of the Indus River is dry, carpeted with vegetation. In 2011, huge stretches of the same land are submerged. Water levels are also visibly higher in Manchhar Lake in the northwest, and the Rann of Kachchh in the southeast.

Conclusion

The value and usefulness of timely collected and processed satellite images are demonstrated through the mapping activities in recent floods. In addition to the free Land sat images, which have limitations in timely revisits and cloud cover requirements, the other images, such as radar images, from the International Charter are a valuable data source. Archived images and GIS data are needed to detect reliable flood extent and estimate potential crop and infrastructure damages. The combined use of temporal optical and radar images are often necessary to achieve this objective. Web mapping capability provides the general public and government agencies with an effective tool for situation awareness and development update.

References

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