



Department of Geology  
and Geography

# Monsoon Flooding of the Indus River, Pakistan 2010

By Jenna Pace

Remote Sensing in  
Environmental Analysis

GGY 422 Spring 2011  
Dr. Eman Ghoneim

## Introduction

In July and August of 2010, heavy monsoon rains believed to be attributed to La Nina, caused the worst flood in the History of Pakistan. Tributaries and levees along the Indus River were overwhelmed by the rain fall and flood waters spread, flooding the low lying river valley. The flood waters destroyed over 69,000 km<sup>2</sup> of crops devastating the country and causing an estimated 2.9 billion dollars in agricultural damage and total damage was estimated at around 20 billion dollars. The research area of interest is located in Punjab Province near the district of Rajanpur, Pakistan and is encircled in red on the above map.



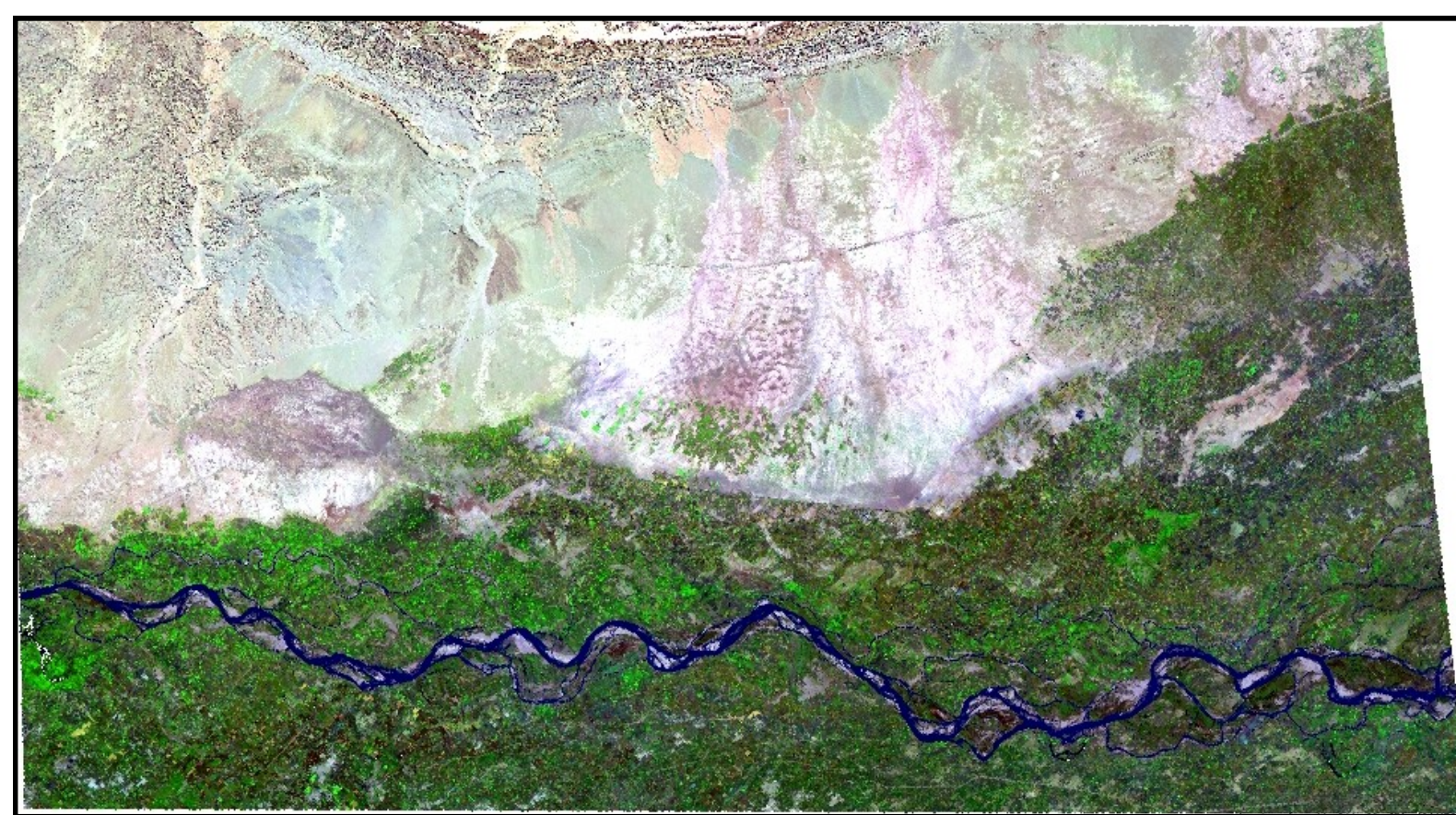
## Research

Remote sensing analysis was used comparing three Landsat 4-5 Thematic Mapper (TM) images to determine the area in km<sup>2</sup> covered by the flood waters.

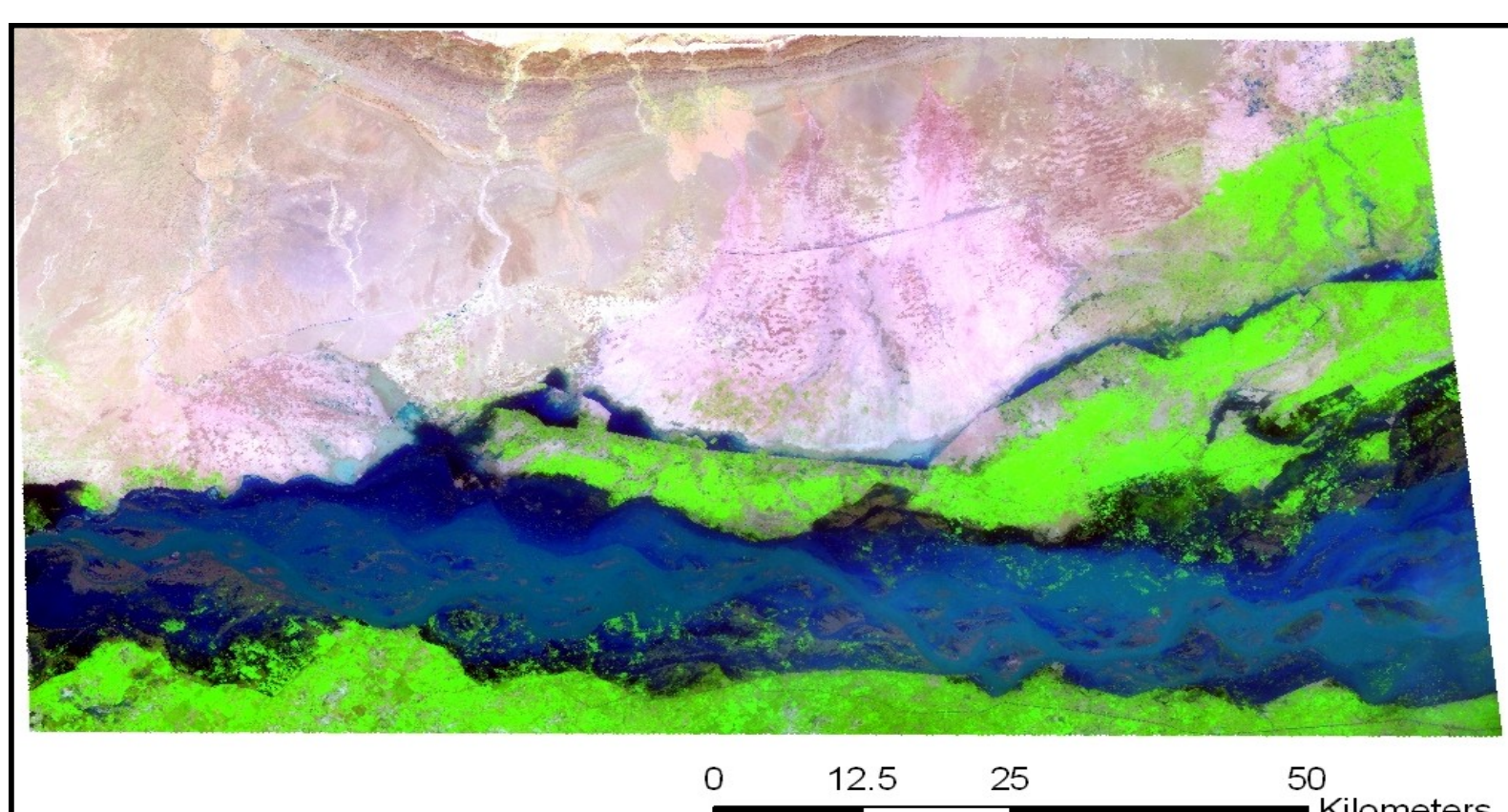
## Methodology

Three Landsat 4-5 TM images were downloaded using GLOVIS (1). The images were all clipped to a uniform area to inhibit cloud coverage for the classification process. Supervised classification along with Google Earth was used to ensure that water, vegetation, non-vegetation, and saturated sand were classified properly. Several Classes of each were created then combined into four total classes to increase the accuracy of the classification. Accuracy Assessments and change detection statistics were then performed on the final classified images.

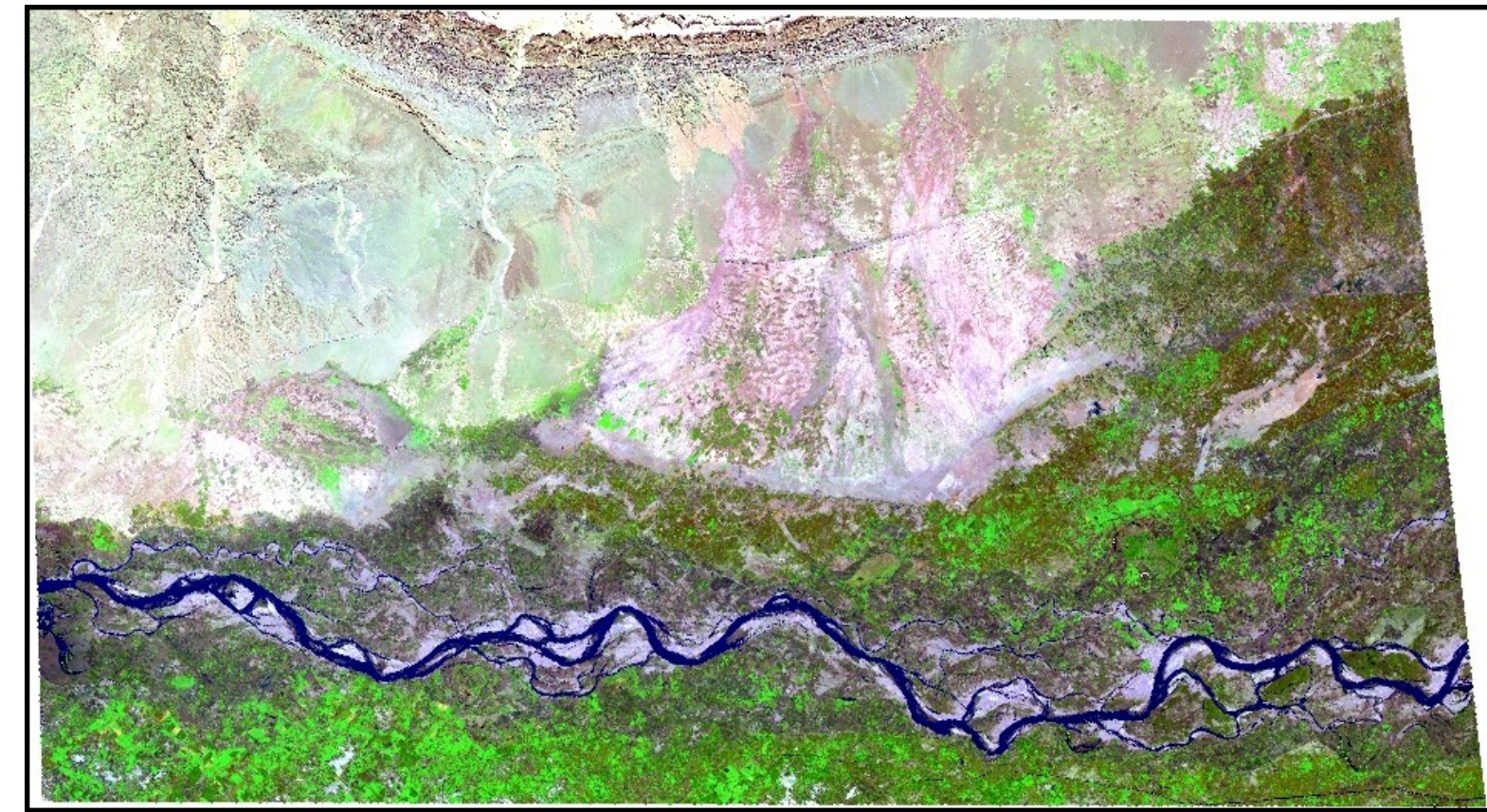
## Clipped Satellite Images



The **December 15, 2009** image above illustrates the Indus River before the monsoon rains and was chosen based on little to no cloud coverage. Bands 5,4,2 were used to emphasize water on all clipped satellite images.



The **August 28, 2010** satellite image above was used to determine the area flooded around the Indus River.

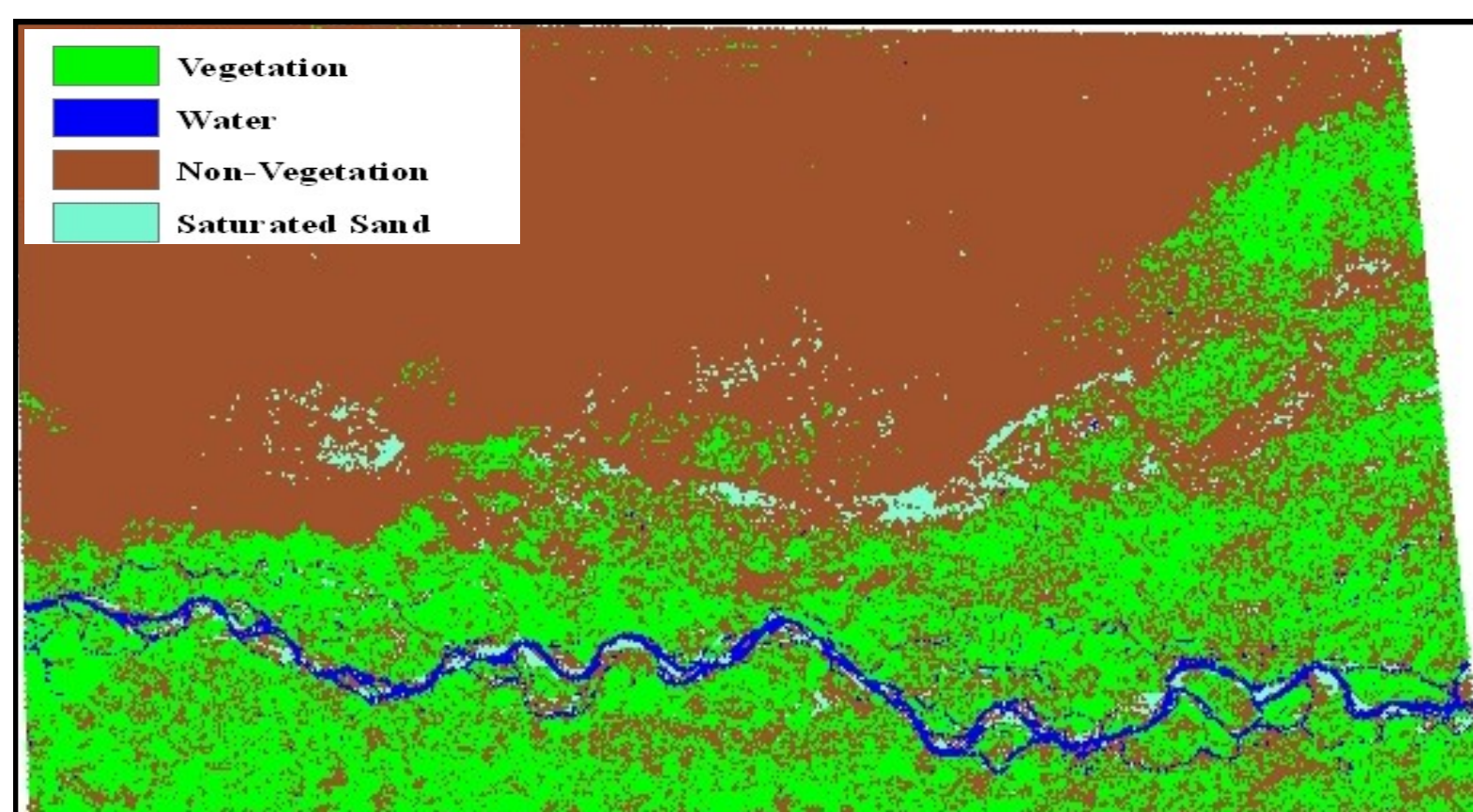


The **December 2, 2010** image above was chosen to coincide with the December 2009 image due to seasonal rainfall and is used to illustrate the Indus River post flood.

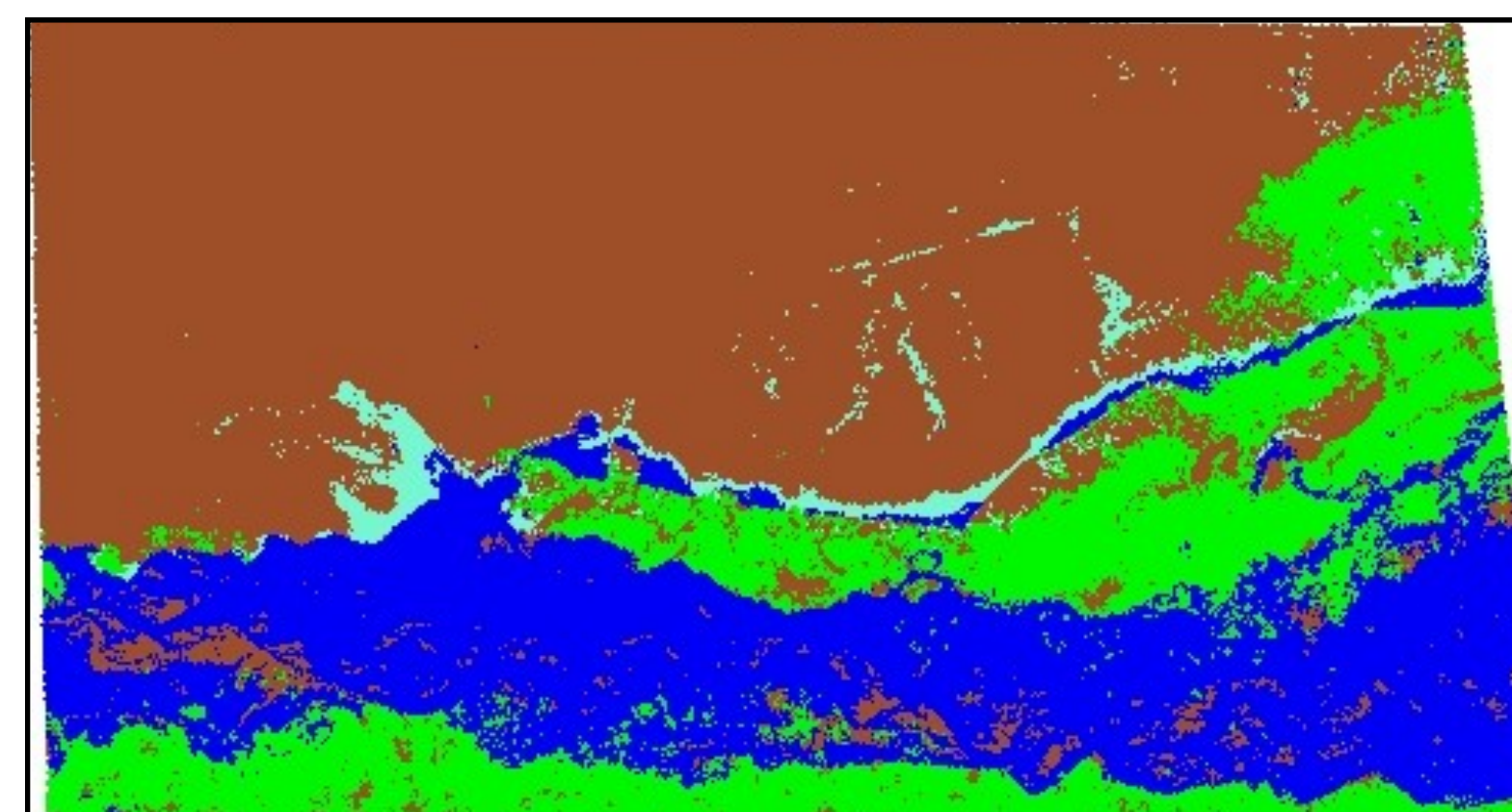
## Classified Satellite Images

The images below are the classified products of the clipped satellite images and were used to calculate accuracy assessment and change detection statistics. All satellite images were classified using Supervised classification with the maximum likelihood. Polygons of vegetation, non-vegetation, saturated sand, and water were all carefully selected using cross referencing of Google Earth to ensure accuracy.

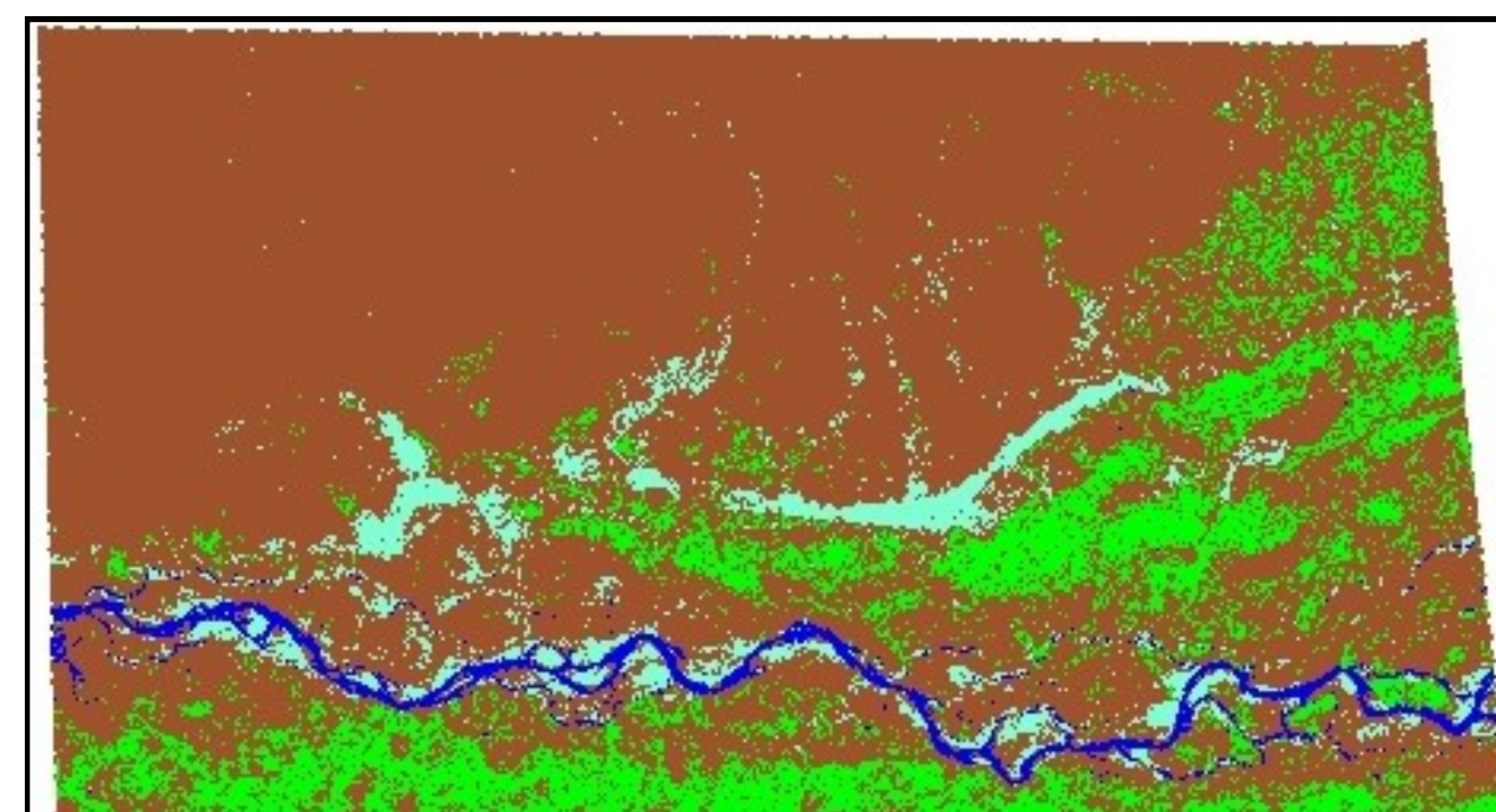
### December 15, 2009 97% accuracy



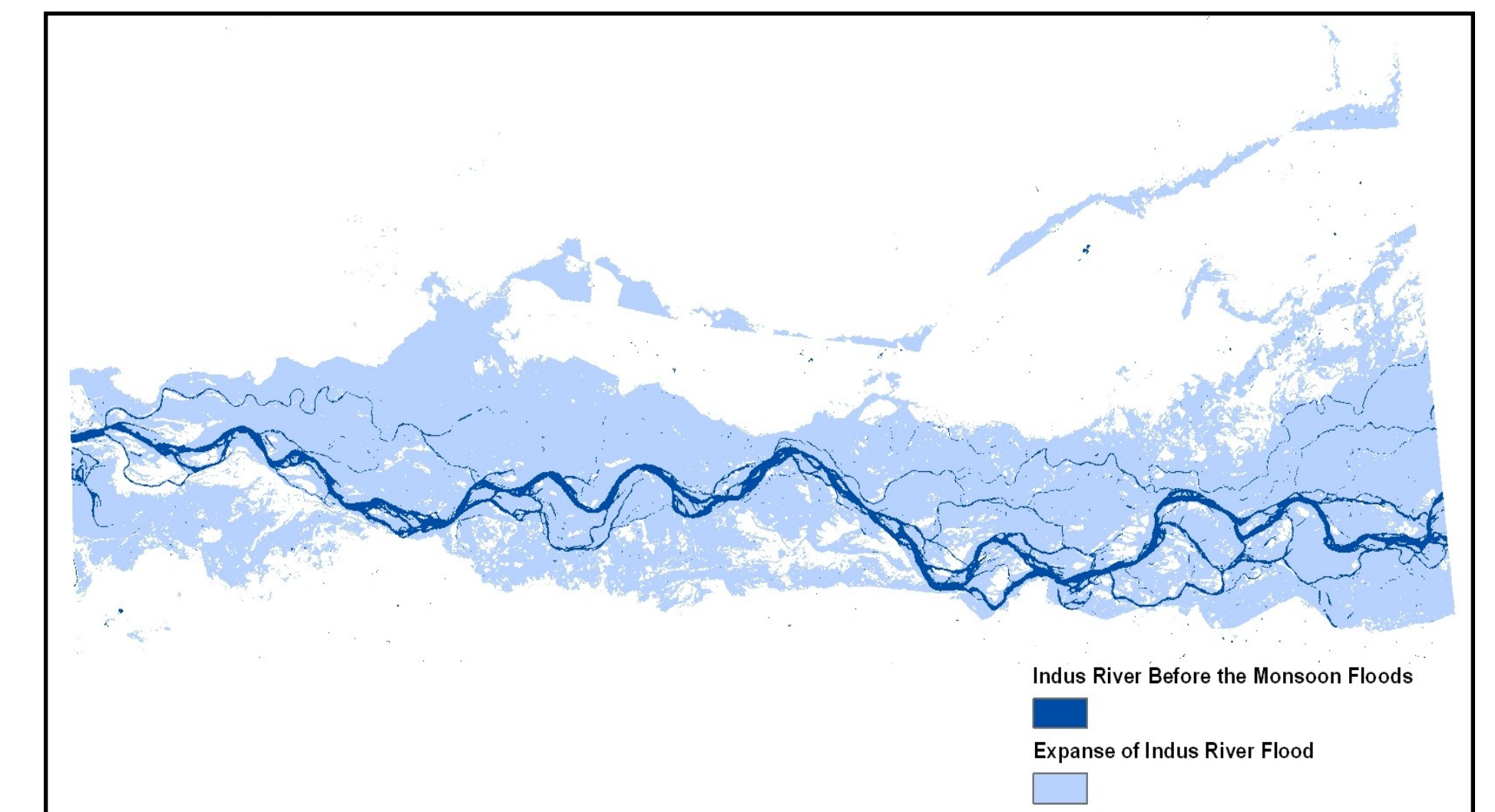
### August 28, 2010 93% accuracy



### December 2, 2010 99% accuracy



## Visual Comparison of Indus River pre-flood and flood

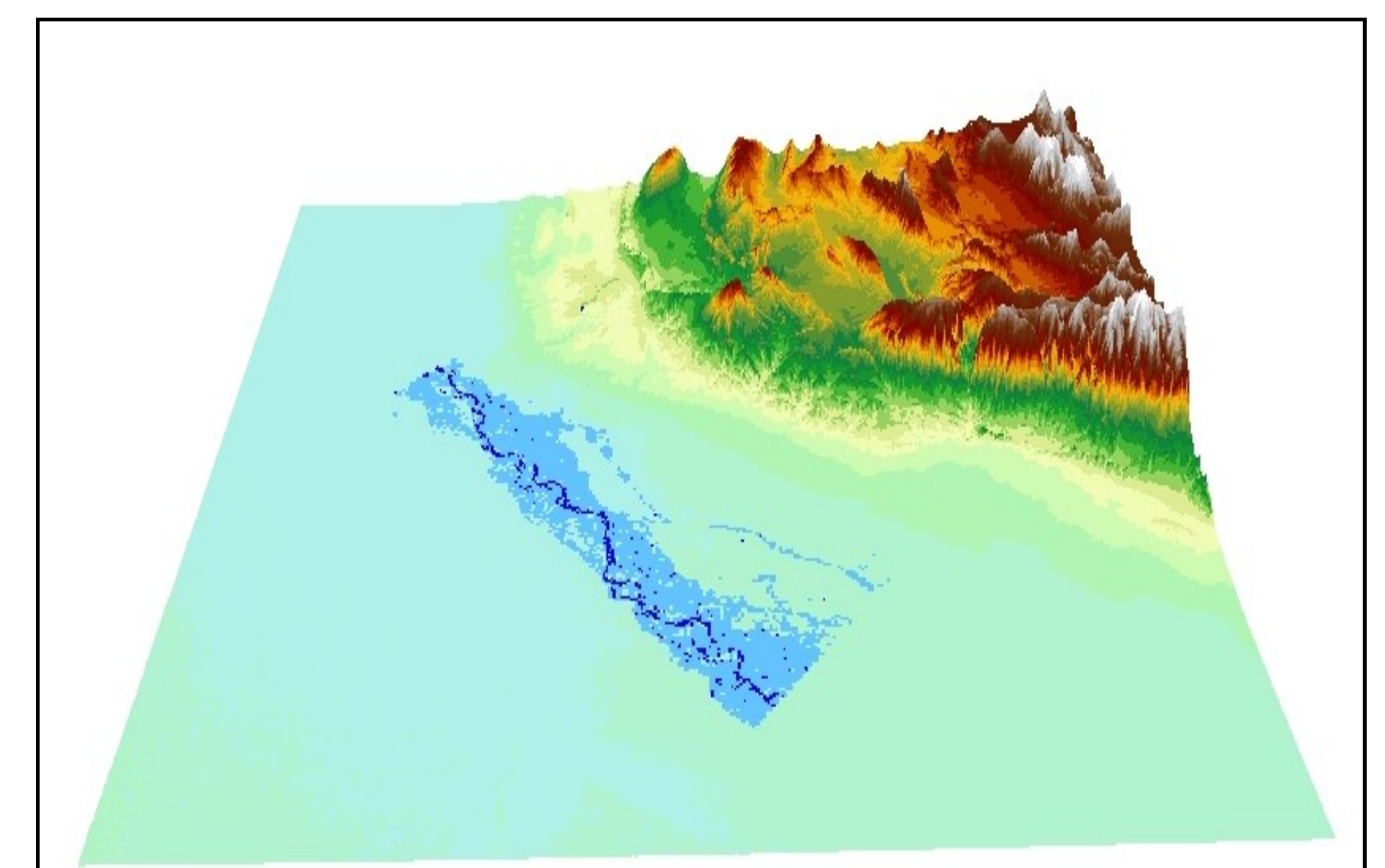


## Change Detection

Change detection (CD) Statistics were calculated based on the classified images. The December 15, 2009 satellite image was compared with the August 28, 2010 image and analysis of the two determined that there was an increase of 1,790.90 km<sup>2</sup> of water surrounding the Indus River. The August 28, 2010 satellite image was then compared to the post-flood December 2, 2010 image and change detection determined that there was a decrease of 1,788.40 km<sup>2</sup> of water and an increase of 215 km<sup>2</sup> of saturated sand.

Change Detection Analysis	Total area km <sup>2</sup> of Water	%Change of Water
Pre-flood December 2009	163.84	
Flood August 2010	1954.74	Gained 91.4%
Post-flood December 2010	166.35	Lost 91.5%

## Digital Elevation Model



Flood waters are depicted in light blue and pre-flooded river depicted in dark blue are overlain on a digital elevation model of the region. Monsoon waters washed down the mountainous region and flooded the River valley.

## Acknowledgments

Special thanks to Dr. Ghoneim, Sam Woolard and Seth Rose

## References

- DEM data retrieved from <http://srtm.csi.giar.org/>
- Imagery retrieved from GLOVIS
- NASA Earth Observatory, Natural Hazards. Unusually Intense Monsoon Rains. (Aug. 12, 2010.) Accessed April 20, 2011 <http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=45177>
- World Food Program. Pakistan Floods Impact Assessment September 2010. Accessed March 17, 2011. WFP.org