Land Use/Land Cover Change in the Ostional Catchment in Rivas, Nicaragua between 2005 - 2015

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Introduction and Background

In Central America, rapid land use and land cover (LULC) change has led to significant loss of primary forest and mangrove estuaries, depletion of soils, and increased pollution and nutrients in waterways[1]. However, there is limited knowledge of water resources and a lack of long-term hydrometeorological data in this region. In areas that lack long-term hydrometeorological and water resource data, change detection analysis of remotely-sensed images can identify and track LULC change and provide insight to how these changes may affect the spatio-temporal hydrologic response.

The tropics are one of the hardest regions to map using remote sensing techniques due to the atmospheric conditions that create an opacity to certain wavelengths. This region has high cloud cover, water vapor, carbon dioxide, and ozone that scatter and absorb visible and near infra-red sensors[2]. Although RS analysis of tropics is challenging due to the atmospheric conditions, it can provide information of this region to better understand the relationship between human activities and natural processes.

We use high-resolution imagery from DigitalGlobe's constellation of satellites obtained through an imagery grant from the DigitalGlobe Foundation to assess the change between satellite images between 2005 & 2015 in Ostional, Rivas, Nicaragua.

Purpose:

- To determine the recent LULC changes within the catchment to better understand how these changes may affect the catchments' hydrologic processes.

Objective:

- Use image differencing in ENVI Classic Software to compare the LULC change overtime.

Study Area:

The project area lies within the Ostional catchment in Rivas, Nicaragua along the Pacific Coastal Plain of Nicaragua (Figure 1)[3]. This mid-size catchment has an area of ~40 km^2 and a length of ~10 km long. A fishing community is located near the estuary and a recently constructed bridge provides access in and out of the only road through town. Mangroves along the mouth of the river act as important sediment traps and stabilize and protect the beach for multiple threatened and endangered turtles. Upstream, there are two small rural villages, Monte Cristo and San Antonio.

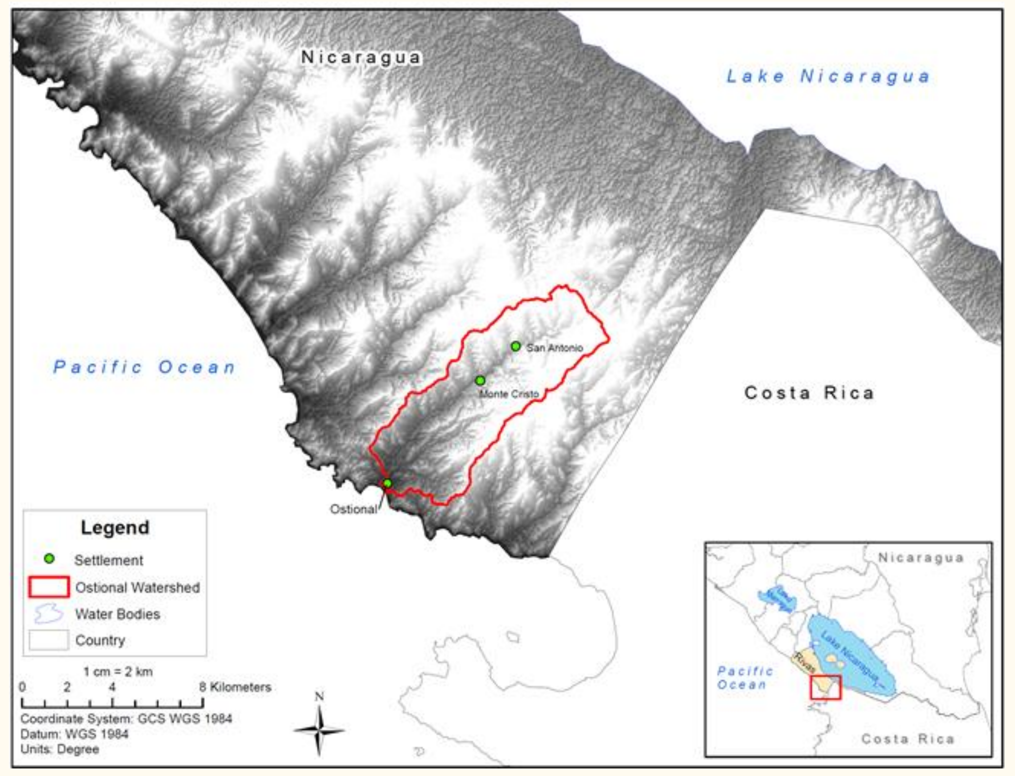

Figure 1: Study location of the Ostional watershed in Rivas, Nicaragua

Methods

Data:

- 7 high-resolution satellite scenes of Ostional between 2005 to 2017 that had less than 20% cloud cover and/or 100% image coverage from DigitalGlobe's constellation of satellites

Analysis:

- **LULC Supervised Classification:** forest, agricultural land, water, bare ground, reflectance

Figure 2 : WV02 Satellite Image of Ostional, Rivas, Nicaragua May 22, 2015

Table 1: Satellite Sensor Characteristics

Satellite	Spectral Resolution	Spectral Ranges for Analysis	Dates	Cloud Cover	Area Off Nadir	Sun Elevation
QB02	2.62 m @ Nadir 2.90 m @ 20° Off-Nadir	4 MS Bands 450-520 nm (blue) 520-600 nm (green) 625-695 nm (red) 760-900 nm (near IR)	02-28-2005	14.2%	16.2%	61.1°
IKONOS	3.2 m @ Nadir	4 MS Bands 450-520 nm (blue) 520-600 nm (green) 625-695 nm (red) 760-900 nm (near IR)	09-25-2009	40.0%	24.5%	66.3°
			09-25-2009	35.0%	18.0%	66.5°
WV-02	2.08 m @ 20° Off-Nadir	8 MS Bands 450-510 nm (blue) 510-580 nm (green) 630-690 nm (red) 770–895 (near IR-1)	02-21-2011	23.6%	11.0%	60.9°
			02-21-2011	21.6%	17.1%	61.1°
			12-10-2011	1.1%	24.2%	53.7°
			04-17-2015	5.0%	7.6%	71.9°
			05-22-2015	3.7%	24.2%	72°
			06-19-2017	44.1%	18.8%	69.4°

Change Detection Analysis:

Table 2: Change Class

Change Class	Threshold
Change (+)	> 0.1
No change	> -0.1 to < 0.1
Change (-)	> 0.1

- We aimed for 90% accuracy using an error matrix to determine the omission/ commission errors and overall accuracy of each category.

Results

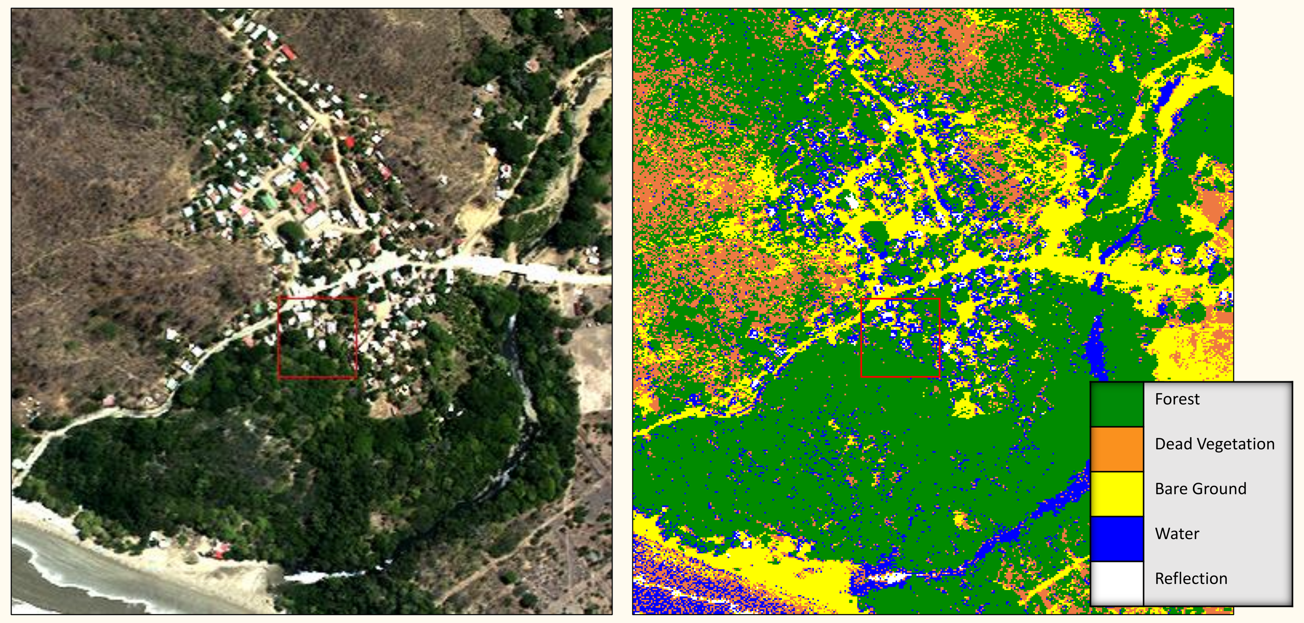

Figure 3: (left) WV-02 Image of Ostional, Rivas, Nicaragua (05/22/2015) (right) Supervised Land Use Classification (Mahalanobis Distance)

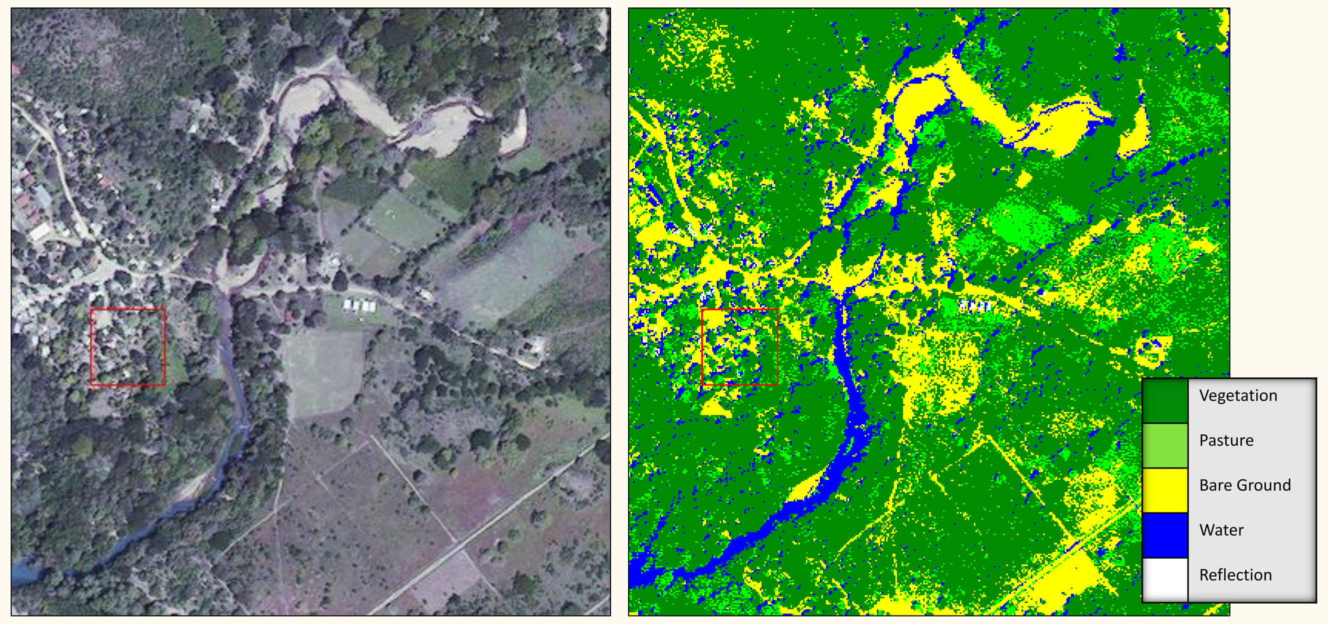

Figure 4: (left) WV-02 Image of Ostional, Rivas, Nicaragua (10/10/2011) (right) Supervised Land Use Classification (Mahalanobis Distance)

Change Class	Percent (%) Image
Change (+)	43.2407
No change	39.2351
Change (-)	17.5242

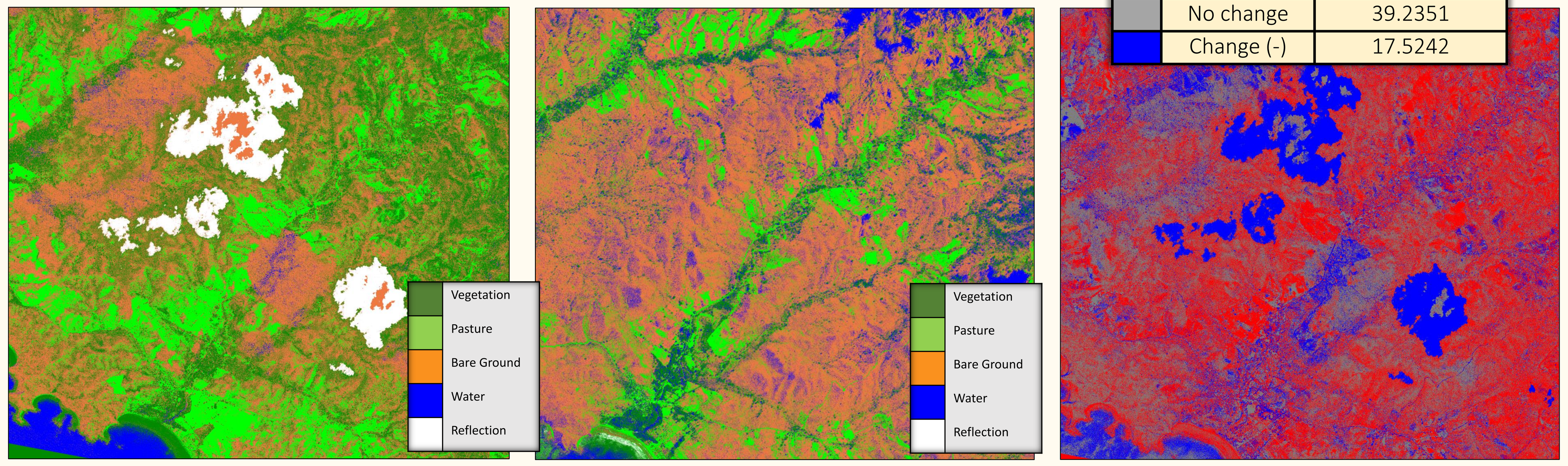

Figure 5: (left) Supervised Land Use Classification (Mahalanobis Distance) of entire QB02 image from February 28, 2005, (middle) Supervised Land Use Classification (Mahalanobis Distance) of WV02 Image from May 22, 2015 (right) percent change between image classifications

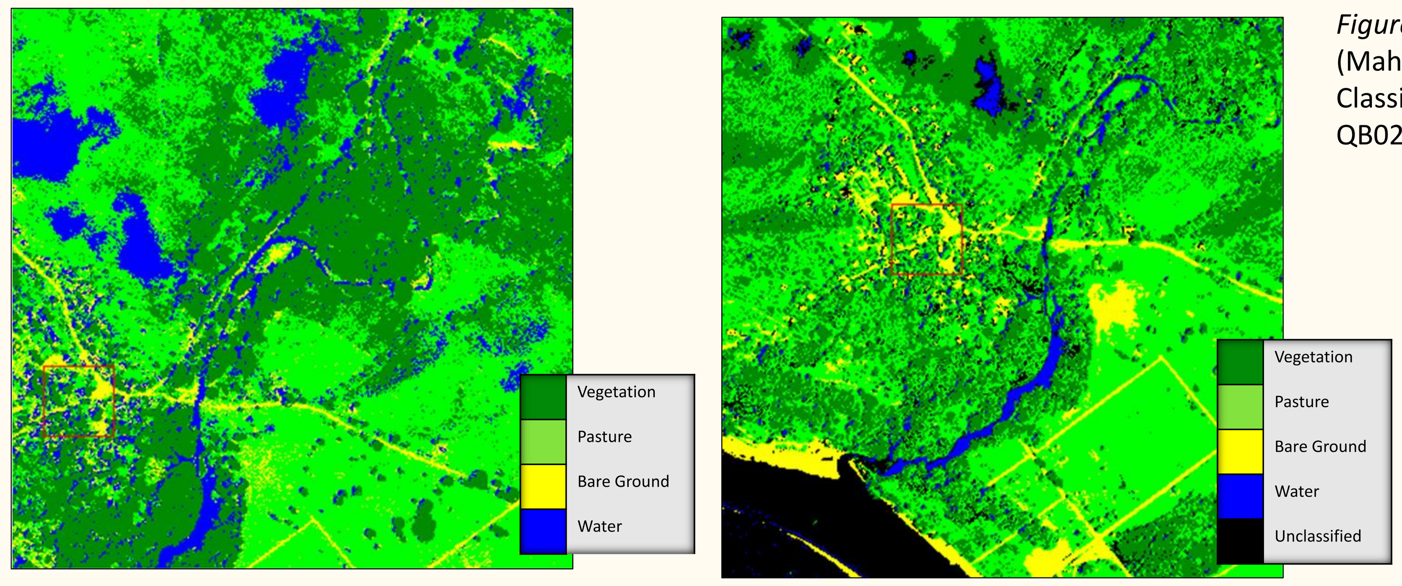

Figure 6: (left) Supervised Land Use Classification (Mahalanobis Distance) and (right) Unsupervised Classification (K-Means) of Ostional, Rivas, Nicaragua QB02 Image (02/28/2005)

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Overall Accuracy = (856296/1282375)  66.7742%
Kappa Coefficient = 0.5169
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Class	Commission (Percent)	Omission (Percent)
Vegetation [G	57.62	7.78
Pasture [Gree	17.65	37.58
Water [Blue]	12.73	59.40
Reflectance [	0.00	41.80

Class	Prod. Acc. (Percent)	User Acc. (Percent)
Vegetation [G	92.22	42.38
Pasture [Gree	62.42	82.35
Water [Blue]	40.60	87.27
Reflectance [	58.20	100.00

Discussion and Conclusion

Next Steps:

- Comparison between Supervised and Unsupervised Classification indicates need for ground-truthing land cover classes in the field (ie: point cloud + buffer area)
- Seasonality & land cover type affects both spectral reflectance and the reference training data
  - Distinguish between permanent and seasonal features
- Prepossess images from different sensors for further analysis of change over time

Conclusions: Pacific coastal catchments and their associated features are vulnerable to land-use and changing climatic patterns. The Ostional catchment ideal to conduct this analysis because a major coastal highway is planned with roadway expansion already implemented. Significant LULC change and flow and sediment alteration is expected to occur. Furthermore, potential alteration of the mangroves and beach would affect threatened and endangered nesting habitats for sea turtles. Remote sensing using high-resolution imagery will enhance our understanding of LULC change through time in remote tropical dry-forest regions. There is great potential to use Supervised Classification of high-resolution imagery to analyze land cover statistics of tropical dry-forest regions.

References:.

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