**Lower Omo Food Security & Agriculture**

*Mapping Land Cover Change in Unprotected and Protected Areas in the Lower Omo River Valley, Ethiopia*

**Project Team**

***Project Team:***

Chiara Phillips (Project Lead)

Stacy Armbruster

Lauren Lad

Matison Lakstigala

***Advisors & Mentors:***

Dr. Paul Evangelista (Colorado State University, Natural Resource Ecology Laboratory)

Dr. Catherine Jarnevich (United States Geological Survey, Fort Collins Science Center)

Nicholas Young (Colorado State University, Natural Resource Ecology Laboratory)

Peder Engelstad (Colorado State University, Natural Resource Ecology Laboratory)

Tony Vorster (Colorado State University, Natural Resource Ecology Laboratory)

**Project Overview**

***Project Synopsis:*** This project used Landsat and Shuttle Radar Topography Mission imagery from January 1st to May 1st of 1994 to 2019 to provide partners at the Ethiopian Wildlife Conservation Authority with maps that show and quantify the land cover change in unprotected and protected areas between the years 1994, 2010, and 2018 in the Lower Omo River Valley. The analysis of these classification maps within and outside of protected areas provided the partners with quantitative data on the location, magnitude, and timeline of land cover change in this culturally and ecologically significant region.

***Abstract:***

Ethiopia is home to unique wildlife, biodiversity, and ecosystem services and, like much of the world, is undergoing population growth, development, and land use change. As a result, some biodiverse regions may be at risk of being urbanized, cultivated as agricultural plots, or losing access to water bodies that are essential for maintaining both terrestrial and aquatic life. The DEVELOP team partnered with the Ethiopian Wildlife Conservation Authority to quantify the land cover change between the years 1994, 2010, and 2018. The team utilized Ethiopia’s dry season (January to May) for training point development which was crucial in differentiating the level of greenness between the four land cover classes: water, natural vegetation, cultivated land, and bare ground. The study area covered 62,000 km2 of the Lower Omo River Valley and includes eight protected areas. We used Landsat 5 Thematic Mapper, Landsat 7 Enhanced Thematic Mapper Plus, Landsat 8 Operational Land Imager, and Shuttle Radar Topography Mission imagery within Google Earth Engine to employ a Random Forest Classifier and identify these four distinct classes. For each of our supervised classifications, overall model accuracy was between 83% (2018) and 89% (1994). Between 1994 and 2018, the Lower Omo Valley experienced an overall increase of 258.57% in water bodies and 291.23% in cultivated areas, while experiencing an 8.91% decrease in natural vegetation and 18.76% bare ground. There was an increase in water bodies and cultivated land and a decrease in natural vegetation and bare ground in unprotected areas and all protected areas. However, protected areas disproportionately experienced an increase in land cover change, including Tama Community Conservation Area which saw a 17,272.33% increase between 1994 and 2018.

***Keywords:***

remote sensing, Landsat, Normalized Difference Vegetation Index, Tasseled Cap, Random Forest, land cover classification

***National Application Area Addressed:*** Food Security & Agriculture

***Study Location:*** Ethiopia, Lower Omo River Valley

***Study Period:*** 1994 to 2018 (January to May)

***Community Concerns:***

* Land cover composition is a significant variable that contributes to the survival of local biodiversity and the prevention of invasive species.
* As this region develops, both unprotected and protected areas are undergoing land cover and land use change that has yet to be analyzed.

***Project Objectives:***

* Classify land cover from 1994 to 2018 using Random Forest in Google Earth Engine (GEE)
* Create a time series analysis to understand the rate and spatial extent of the land cover change
* Analyze the acreage of land cover change for both protected and unprotected land

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Ethiopian Wildlife Conservation Authority** | Dr. Fanuel Kebede, Wildlife Research and Monitoring Directorate Director | End User | No |

***Decision-Making Practices & Policies:***

The Ethiopian Wildlife Conservation Authority (EWCA) is the governing agency for all protected lands and wildlife in Ethiopia. EWCA makes decisions related to protected area enforcement and regulation and provides recommendations to policymakers at the national level. They use multiple strategies to assess the status of wildlife species, to evaluate the current condition of protected areas, and to make policy recommendations. They have maps of protected areas and other basic GIS-based features but rely on in-field surveys for analysis.

***Project Benefit to End User:***

This research will provide an analysis of land cover change that is occurring in this distinctive landscape. Our end user can use these products to provide context to the speed at which land cover change is happening, to visually analyze the spatial extent of these changes, and to contextualize how this has affected protected and unprotected areas. These products will improve the effectiveness and efficiency of their conservation work by covering a large spatial area that would not be feasible without using NASA Earth observations and remote sensing.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Surface reflectance, normalized difference vegetation index (NDVI), normalized difference wetness index (NDWI), tasseled cap brightness, greenness, and wetness | This dataset provided the temporal (16 days)  and spatial (30 m) resolution needed to derive  environmental predictive variables for displaying and modeling land cover change in LandTrendr and the Random Forest supervised classification. |
| **Landsat 8 OLI** | Surface reflectance, NDVI, NDWI, tasseled cap brightness, greenness, and wetness | This dataset provided the temporal (16 days)  and spatial (30 m) resolution needed to derive  environmental predictive variables for displaying and modeling land cover change in LandTrendr and the Random Forest supervised classification. |
| **SRTM** | Elevation | This dataset provided an elevation layer used to differentiate between land cover types within the Random Forest supervised classification. |
| **Landsat 7 ETM+** | NDVI | This dataset provided the temporal (16 days)  and spatial (30 m) resolution needed to display  land cover change in LandTrendr. |

***Ancillary Datasets:***

* Ethiopian Wildlife Conservation Authority Protected Area Spatial Database – Polygons of protected areas used as a comparison of where land cover change occurs relative to protected areas in Ethiopia
* Land Cover Training Dataset for 1994, 2010, and 2018 (Water, Natural Vegetation, Cultivated Land, Bare Ground) – Ocularly sampled points of presence for each land cover class used as training points for the Random Forest classifier

***Modeling:***

* Random Forest (RF) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center) – Classification model of presence and absence of land cover change

***Software & Scripting:***

* Google Earth Engine API – Large-scale raster analysis
* ArcMap 10.6.1 – Raster processing and end product generation
* QGIS 3.4 – Raster and vector processing and end product generation
* LandTrendr – Package of algorithms to extract spectral information from time-series imagery

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Land Cover Change Maps** | Landsat 5 TM Landsat 7 ETM+  Landsat 8 OLI  SRTM | Maps helped decision-makers understand the dynamic changes in land cover in the Omo River Valley over the last 20 years. | I |
| **Land Cover Change Timeline and Analysis** | Landsat 5 TM  Landsat 7 ETM+  Landsat 8 OLI  SRTM | The timeline and analysis allowed partners to identify the rate and spatial extent of land cover change over the last 20 years in protected and unprotected areas. | I |
| **Esri StoryMap: Ethiopian Land Cover Change** | N/A | The StoryMap helped in efficiently communicating our findings to partners. | N/A |

**Project Handoff Package**

***Transition Plan:*** At the end of the term, the team hosted a virtual closeout via Webex. In the Fall of 2020, Dr. Evangelista brought the handoff package in person to partners.

***Team POC:*** Chiara Phillips, chiara.m.phillips@gmail.com

***Partner POC:*** Dr. Fanuel Kebede, fanuel.kebede@gmail.com

***Handoff Package:***

* Land Cover Change Maps
* Land Cover Change Timeline and Analysis
* Esri StoryMap: Ethiopian Land Cover Change
* Poster
* Presentation
* Technical Paper

**References**

Fong, C. (2015, January). The scramble for water, land, and oil in the Lower Omo Valley: The consequences of industrialization on people and the environment in the Lower Omo Valley and Lake Turkana. *International Rivers,* 1-15. https://www.internationalrivers.org/sites/default/files/attached-files/the\_scramble\_for\_water\_land\_and\_oil\_in\_the\_lower\_omo\_valley.pdf

Hodbod, J., Tebbs, E., Chan, K., & Sharba, S. (2019). Integrating participatory methods of remote sensing to enhance understanding of ecosystem service dynamics across scales. *Land, 8*(9)*,* 132-162*.* <https://doi.org/10.3390/land8090132>

Yohannes, H., Mohammed, A., & Elias, E. (2017). Land use/land cover dynamics and its impact on biodiversity resources in Abijata Shalla National Park, Central Rift Valley Lakes Region, Ethiopia. *Environmental Science: An Indian Journal, 13*(5), 152-166. https://www.researchgate.net/profile/Hamere\_Yohannes2/publication/321134110\_Land\_UseLand\_Cover\_Dynamics\_and\_Its\_Impact\_on\_Biodiversity\_Resources\_in\_the\_Abijata\_Shalla\_National\_Park\_Central\_Rift\_Valley\_Lakes\_Region\_Ethiopia/links/5a0ee715458515de0329ba2e/Land-Use-Land-Cover-Dynamics-and-Its-Impact-on-Biodiversity-Resources-in-the-Abijata-Shalla-National-Park-Central-Rift-Valley-Lakes-Region-Ethiopia.pdf