Spring 2024 Project Summary

Cali Urban Development

Using NASA Earth Observations to Assess Wetlands and Land Reclamation in Cali, Colombia

Project Team

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Project Overview

Project Synopsis:

Wetlands are vital for ecosystem health and biodiversity but are threatened by urbanization and agricultural expansion. This project investigated the declination of wetlands in Cali, Colombia by developing a time series of wetland extent and land use land cover classification with Landsat 5 TM, Landsat 8 OLI, Landsat 9 OLI-2, Sentinel-2 MSI, Sentinel-1 C-SAR, Suomi-NPP VIIRS and Planetscope data between 2002 and 2023. The end products created by the team included a wetland extent time series, land use land cover change maps, and a map of wetland intrinsic potential over Cali. These data provided partners with a more comprehensive inventory of wetlands within Cali.

Abstract:

Recent research has documented the global decline of wetlands, largely attributed to increased urbanization and agriculture. This NASA DEVELOP study partnered with two local environmental entities in Cali, Colombia: The Fundación Dinamizadores Ambientales and the Departamento Administrativo de Gestión del Medio Ambiente. The team utilized Earth observations to evaluate trends in wetland extent, potential, and land cover in Cali between 2002 and 2023. A supervised classifier was generated within Google Earth Engine to create land use analyses of the region using Landsat 5 TM, Landsat 8 OLI, and Landsat 9 OLI-2imagery. To identify locations of wetland potential within the study area, wetland probability was assessed by inputting PlanetScope, Sentinel-2 MSI, and partner-provided datasets into the Wetland Intrinsic Potential Tool in ArcGIS Pro and R. Data from Sentinel-1 C-SAR, Sentinel 2-MSI, and Suomi-NPP VIIRS were used to evaluate wetland extent using the Wetland Extent 3.0 Tool in Python. Overall, results indicated areas with high wetland potential, particularly in the southeast region where agricultural fields were previously wetlands. Outputs also suggest a vast network of riparian wetlands in Cali. This study did not investigate socioeconomic data as it relates to wetlands, which is a topic suggested for future research. This project included research into links between land use change, wetland extent, and wetland potential, and provided partner organizations with an objective foundation from which they can identify at-risk wetlands and develop community initiatives for wetland management, conservation, and education.

Key Terms:

Cali, Colombia, Wetlands, Wetland Intrinsic Potential Tool, WET 3.0, Land Use Land Cover, SAR, DEM

Application Area: Urban Development *Study Location:* Santiago de Cali, Colombia *Study Period:* January 2002–December 2023

Community Concerns:

- The wetlands within Cali have been degraded heavily since the mid-20th century, resulting in a 99% loss of wetland area.
- The conversion of wetlands for agricultural development, primarily sugarcane crop, has threatened wetlands.
- Declination of wetlands has caused intensified flooding, loss of urban green space, and biodiversity loss.
- The loss of wetlands within urban areas can also intensify the Urban Heat Island effect.

Project Objectives:

- Delineate wetland intrinsic potential.
- Identify wetland extent.
- Map land use & land cover change.

Partner	Overview

Organization	Contact (Name, Position/Title)	Partner Type	Sector
Fundación Dinamizadores Ambientales	Sebastian Oyola, Project Coordinator	End User	International
Departamento Administrativo de Gestión del Medio Ambiente (DAGMA)	Franklin Castillo-Sanchez, Deputy Director of Environmental Quality. Viviana Huetio-Vergara, Environmental Engineer, Urban Environmental Assessment Group. Elidier Gómez, Director, Francy Restrepo Aparicio, Directora Dagma. Viviana María Sánchez Escobar, Líder grupo cambio climático. Monica Londoño.	End User	International

Decision-Making Practices & Policies:

The Departamento Administrativo de Gestión del Medio Ambiente (DAGMA) is the maximum authority in Cali, Colombia in charge of developing diverse programs directed at citizen participation and care of the

environment. The Fundación Dinamizadores Ambientales (FDA) is a non-profit organization that has helped DAGMA for the past 10 years by providing educational and applied tools for the conservation of Cali's natural resources. DAGMA oversees the management and restoration efforts of wetlands with Cali, and relies on field surveys to compile wetland inventory, which creates a limited view of total wetland extent in Cali. Within Cali, DAGMA has the legal charge and authority over the environment, which includes managing wetlands for the municipality. Both institutions have personnel trained in basic remote sensing and geographic information systems (GIS), however, neither has the tools, personnel, and resources to maintain a program on the use of remote sensing tools for resource management. This project will introduce the usage and methodologies of NASA Earth observations to the partners' tool kit.

Earth Observations:		
Platform & Sensor	Parameter	Use
Landsat 5 TM	Landcover	These data were used between 2002 and 2012 to calculate land-use change, create maps, and develop time series analyses.
Landsat 8 OLI	Landcover	These data were used over the past 22 years to calculate land-use change, create maps, and develop time series analyses.
Landsat 9 OLI-2	Landcover	These data were used over the past 3 years to calculate land-use change, create maps, and develop time series analyses.
Sentinel-1 C-SAR	Backscatter	These data were used for inundation classification within the NASA DEVELOP's Wetland Extent Tool (WET)
Sentinel-2 MSI	Modified Normalized Difference Water Index (MNDWI)	These data were used to generate MNDWI for the study area as an input into the Wetland Intrinsic Potential Tool
Suomi-NPP VIIRS	Floodwater fraction	These data were used to calculate floodwater fraction for validation of classification tool.
PlanetScope	Normalized Difference Vegetation Index (NDVI)	These data were used to generate high-resolution NDVI for the study area.

Earth Observations & End Products Overview

Ancillary Datasets:

- Infraestructura de Datos Espaciales de Santiago de Cali Cali soil data for WIP Tool input
- IGAC Local Wetland Extent Dataset Data of all known wetlands within Cali
- Portal Hidroclimatológico Cali Surface water data for calculation of Depth to Water Index
- InSAR DEM –5m resolution DEM, used to derive topographical indices

Models:

- Google Earth Engine Best Available Pixel (POC: Saverio Francini, University of Florence) Generating a cloud-free composite image over the study area
- Wetland Intrinsic Potential Tool (POC: Megan Halabisky, University of Washington) Generating wetland probability raster
- Wetland Extent Tool 3.0 (POC: Mitch Porter, Cultural Site Research and Management Foundation and Bruce Chapman, NASA Jet Propulsion Laboratory) Mapping wetland extent

Software & Coding Languages:

- R 4.3.3 Wetland Intrinsic Potential Tool
- ArcGIS Pro 3.2 Wetland Intrinsic Potential Tool and creating maps
- Google Earth Engine Landsat-derived land classification
- Python 3.12 WET 3.0
- QGIS 3.0 Visualizing GIS data and creating maps
- Anaconda 2.4.2 Import necessary libraries for the Wetland Extent Tool 3.0 workflow
- Jupyter Lab 3.6.7 Analyze and display spatial outputs generated by several models
- RStudio 2023.12.1– Served as integrated developing environment for Wetland Intrinsic Potential Tool

End Products:

End Product	Earth Observations Used	Partner Benefit & Use
Cali Land Cover Classification	Landsat 5 TM, Landsat 8 OLI, Landsat 9 OLI-2	End product will provide partners with long-term data on how wetland extent has evolved over the study period
Cali Wetland Intrinsic Potential	PlanetScope, Sentinel-2 MSI	End product will aid in the partners in expanding their wetland inventory and mapping areas that have high potential for wetland formation.

Product Benefit to End User:

Through the end products generated from the WIP Tool and the Land Cover Classification our partners will be able to enhance their decision-making on two fronts. First, they will have an enhanced understanding of how wetlands in Cali have changed over the course of the previous 20 years, and thus will be more aware of the types of pressures wetlands are facing. Mapping wetland intrinsic potential will provide a more complete inventory of wetlands and can inform what areas in Cali are ripe for future wetland restoration.

Project Continuation Plan:

Within this term, maps of land cover from 2002-2023 and a current map of wetland extent derived from the WIP Tool will be handed off. In future terms, urban heat maps, and socio-economic wetland analysis results will be given to partners.

References

Berberian, L., Harris, K., Porter, M., & Waugh, E. (2023). WET Water Resources: A Google Earth Engine Python API Tool to Automate Wetland Extent Mapping Using Radar Satellite Sensors for Wetland Management and Monitoring. <u>https://ntrs.nasa.gov/citations/20230006078</u>

Davidson, C. N. (2014). How much wetland has the world lost? Long term and recent trends in global wetland area. *Marine and Freshwater Research*, 65, 934-941. DOI:<u>10.1071/MF14173</u>

Flórez-Ayala, C. (Ed.). (2015). Colombia anfibia: un país de humedales. Instituto de investigación de Recursos Biológicos Alexander von Humboldt. <u>http://hdl.handle.net/20.500.11761/9290</u> Halabisky, M., Miller, D., Stewart, A. J., Yahnke, A., Lorigan, D., Brasel, T., & Moskal, L. M. (2023). The Wetland Intrinsic Potential tool: Mapping wetland intrinsic potential through machine learning of multi-scale remote sensing proxies of wetland indicators. *Hydrology and Earth System Sciences*, 27(20), 3687–3699. <u>https://doi.org/10.5194/hess-27-3687-2023</u>