National Aeronautics and Space Administration

SOUTH AFRICA ECOLOGICAL CONSERVATION II

Identifying and Mapping Riparian Areas in South Africa with Earth Observations

Joseph Gibbs

Anjan Rana Magar

Sera Tolgay

Daniella Asturias

DEVELOP

California – JPL | Fall 2024

Introduction to Riparian Zones

Riparian zones are transitional areas that exist between riverine and terrestrial ecosystems.

They are critical ecological areas that support high biodiversity and provide essential ecosystem services, including:

- Bank Stabilization
- Flood Control
- Water Filtering
- Habitat Provisioning

Orange River, Northern Cape Province, South Africa
Image Credit: Nancy Job

Community Concerns

Riparian zones in South Africa are threatened, endangering vital ecosystem services.

Climate change is expected to exacerbate these threats into the future.

Local communities rely on healthy riparian ecosystems for environmental health & economic stability.

Project Partners

- The South African National Biodiversity Institute (SANBI)
- Western Cape Government, Department of Environmental Affairs and Development Planning

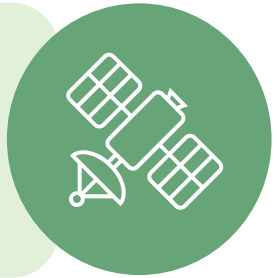
Our partners face challenges in conserving riparian ecosystem due to **limited geospatial data**, hindering management efforts.

This project will help our project partners identify target areas for riparian conservation and understand their distribution across the nation through a **GIS-based inventory of riparian zones**.

Grotto Beach, Hermanus, South Africa
Image Credit: Kerry Cawse-Nicholson

Objectives

Determine potential riparian zones across South Africa



Estimate the extent of woody riparian vegetation within riparian zones nationwide

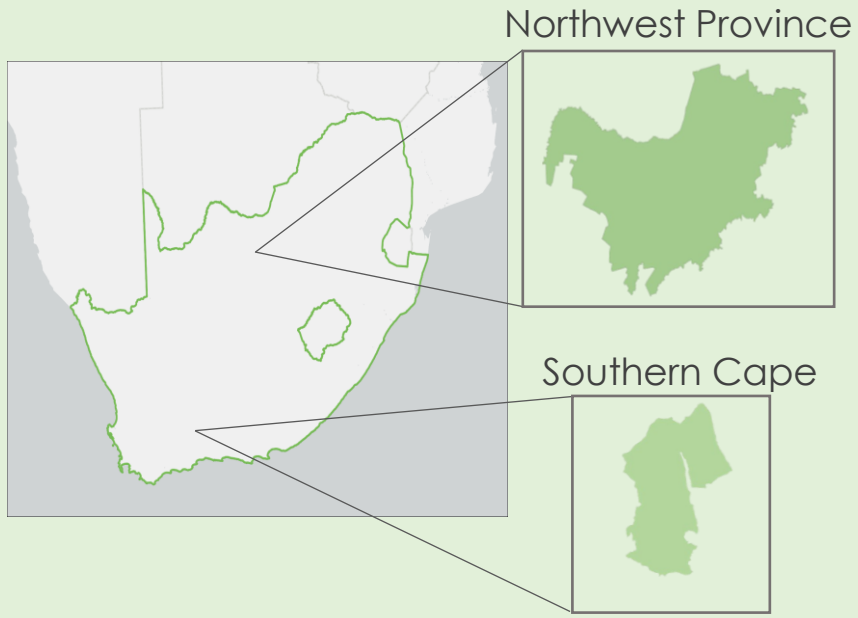
DEVELOP a scalable and reproduceable methodology for future use

Riparian Mapping (DEVELOP Summer '24)

Part 1 Overview

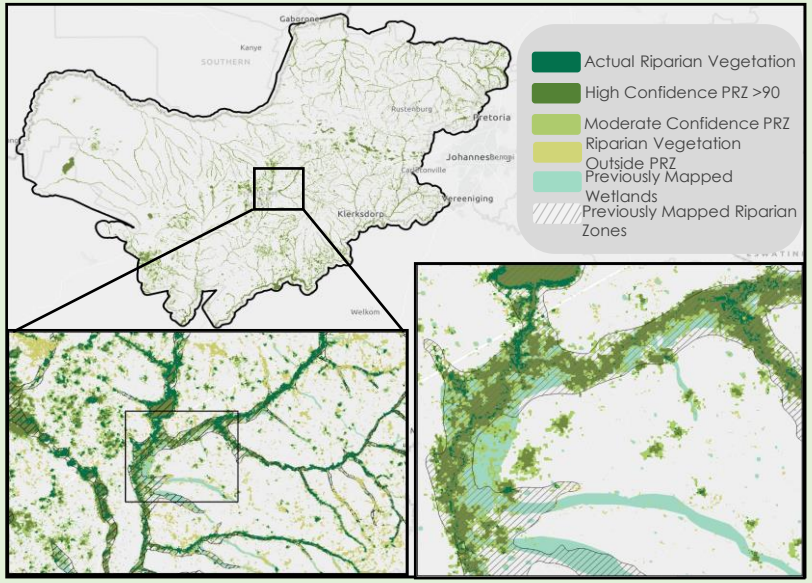
- Mapped riparian zones in two pilot study sites:

Study Area

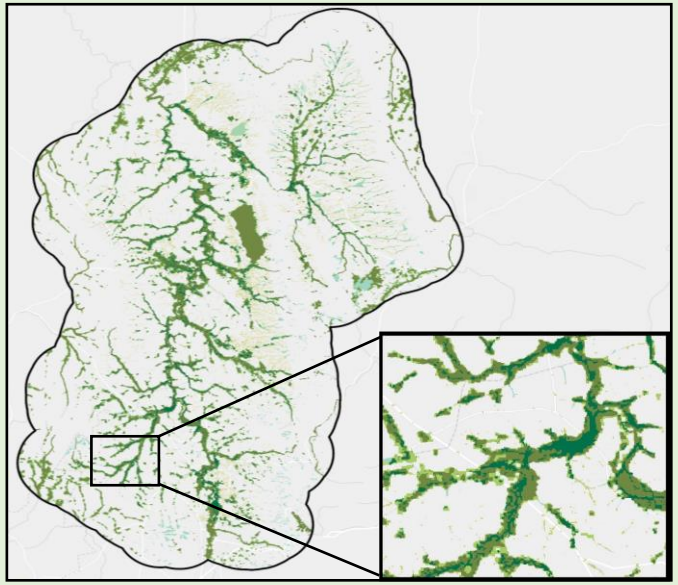


Results

Northwest Province



Southern Cape



Findings

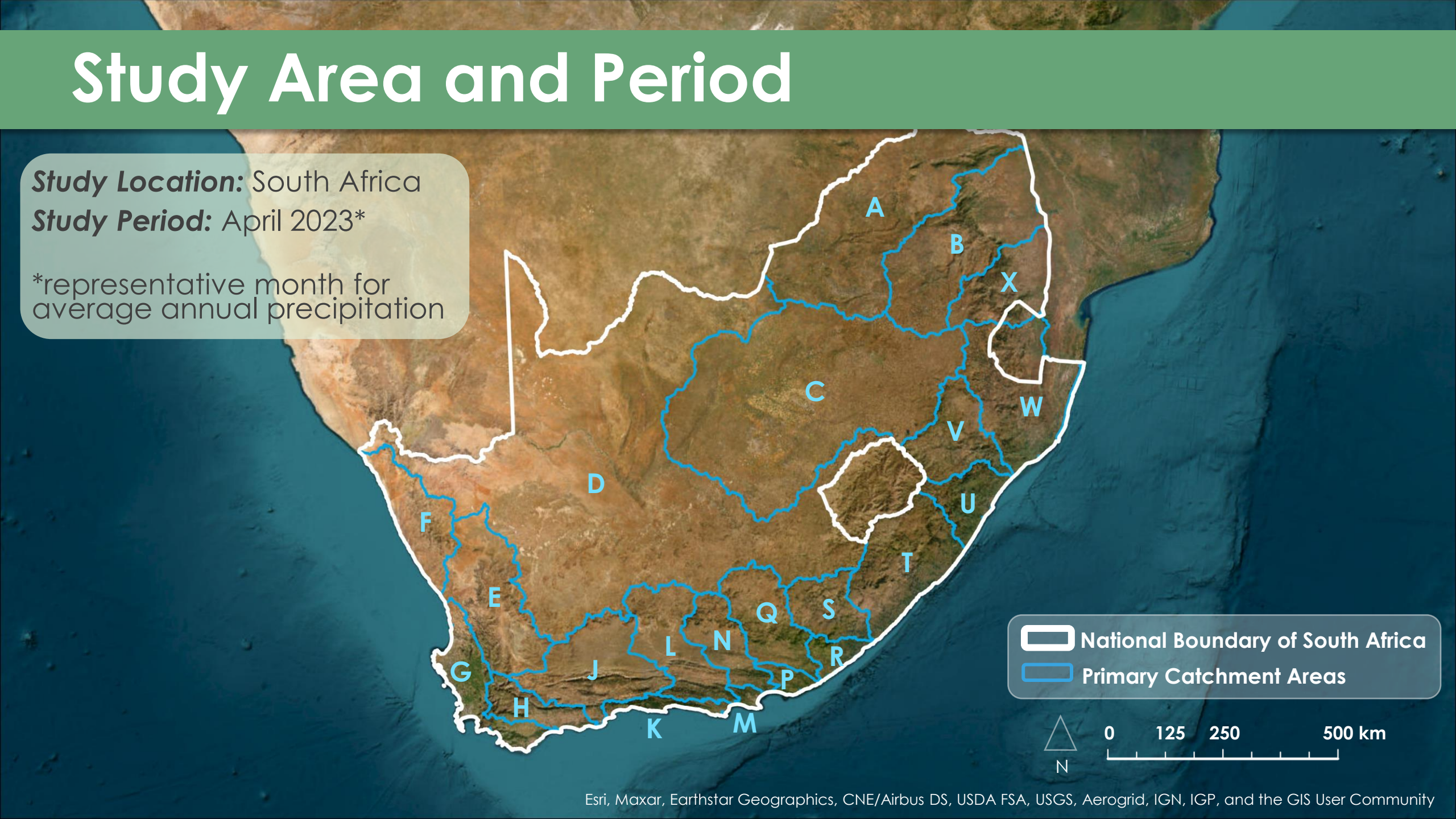
Demonstrated the feasibility of using Earth observations to delineate riparian zones

Highlighted critical conservation areas

Study Area and Period

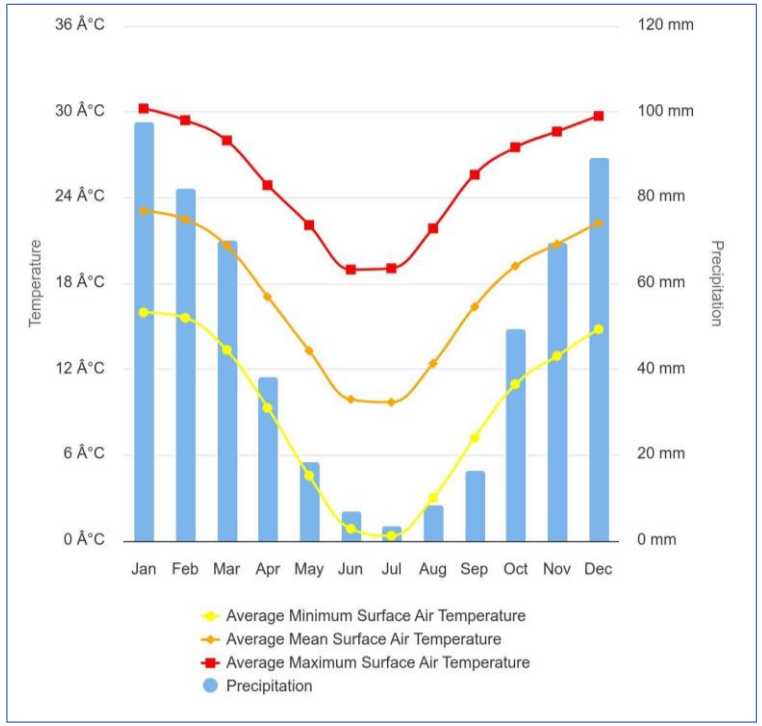
Study Location: South Africa
Study Period: April 2023*

*representative month for average annual precipitation

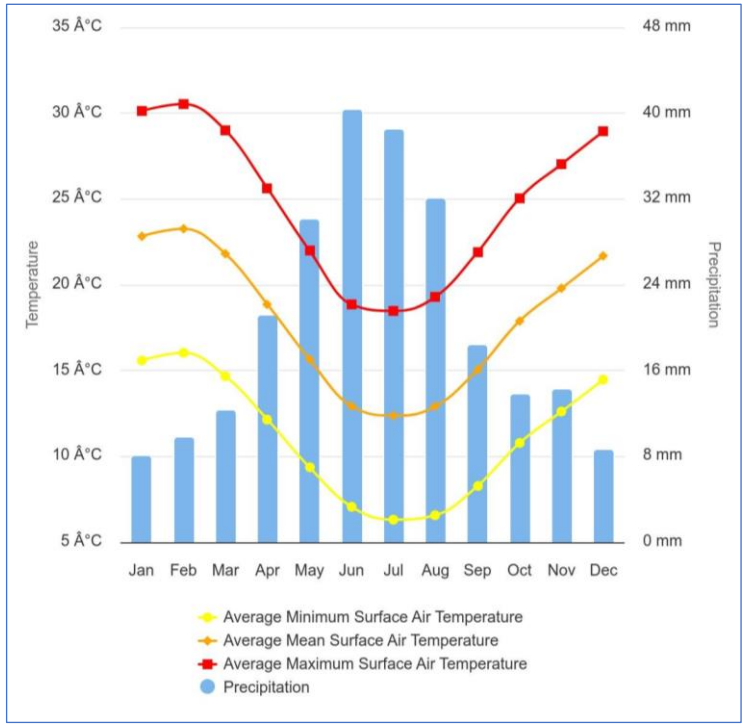


Study Period Considerations

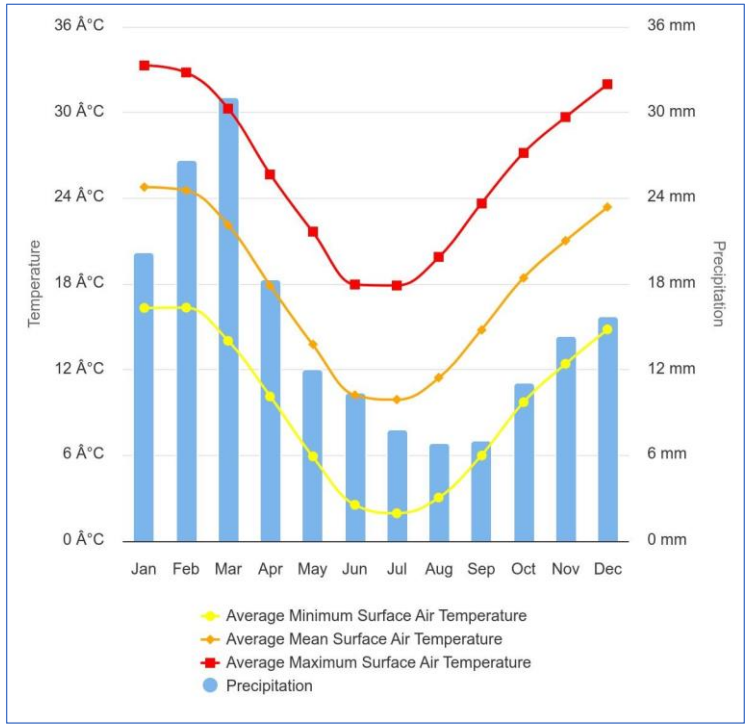
- The **wettest and driest three-month periods of the year,** based on most recent 30-year climate averages (1991 – 2020), vary significantly from region to region in South Africa.



Monthly Climatology of Northeast Provinces (Watershed # ESA162937)
Wet Period: December-January-February



Monthly Climatology of Western Cape (Watershed #ESA001503)
Wet Period: June-July-August

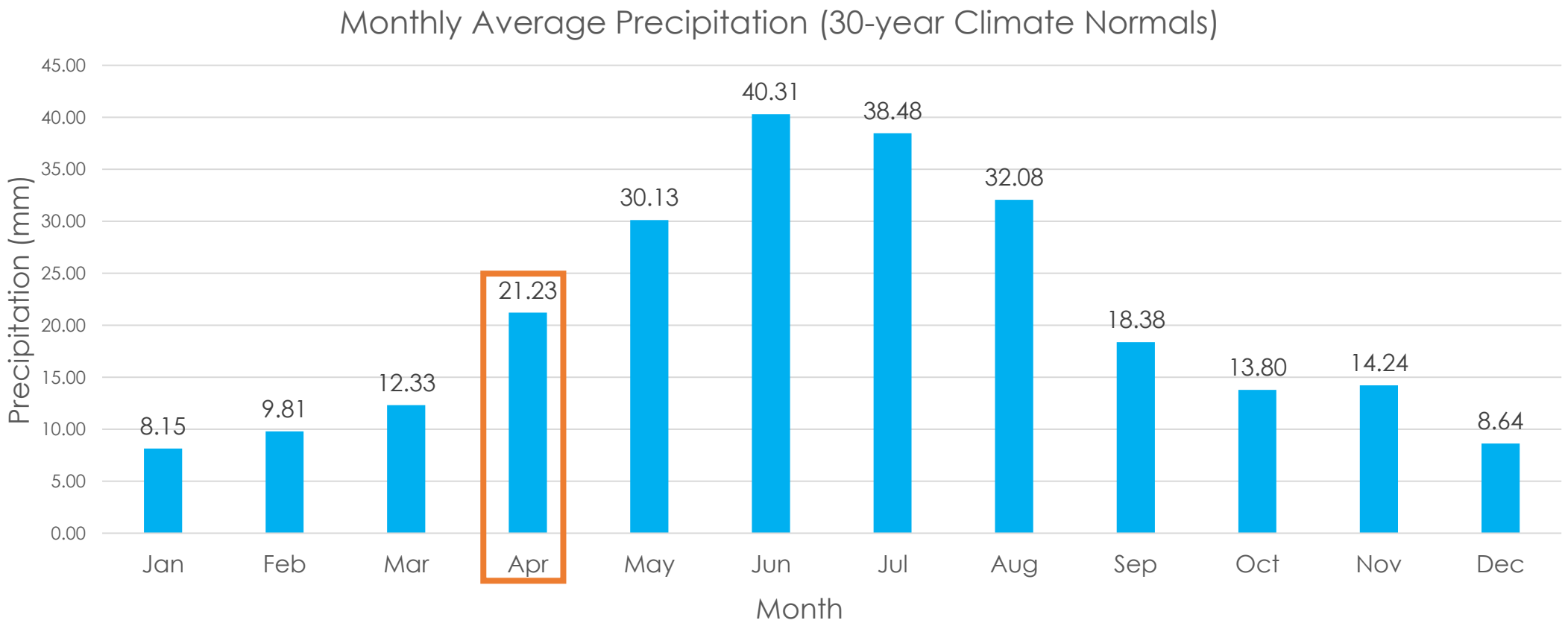


Monthly Climatology of Northern Cape and Semi-Arid Regions (Watershed #ESA162620)
Wet Period: January-February-March

Image Credit: World Bank Climate Change Knowledge Portal

Study Period Selection

- Based on 30-year climate normals (1991 – 2020), average annual precipitation in South Africa is 20.6 mm.

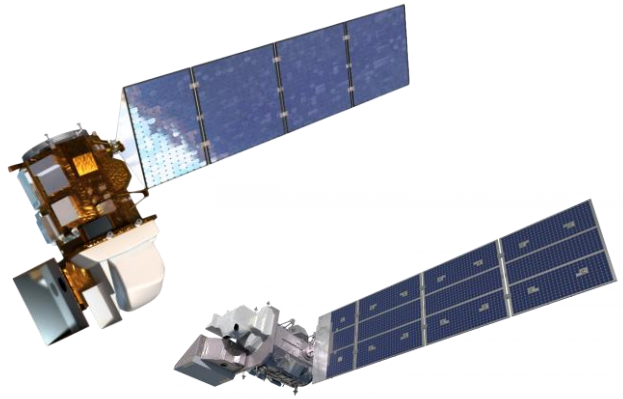


The month of April was selected as the representative study period since its precipitation levels closely align with the annual average.

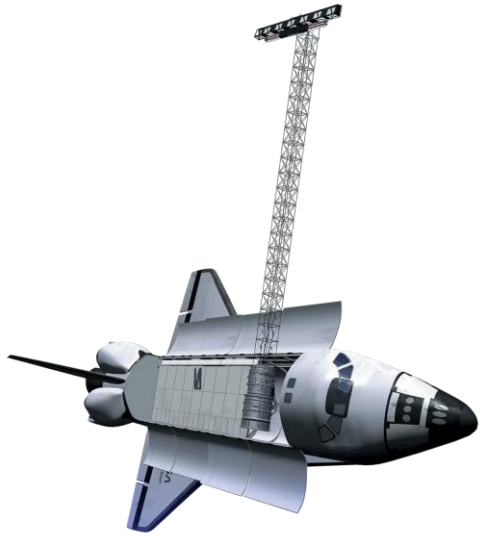
Source: World Bank Climate Change Knowledge Portal, Observed, historical data is produced by the Climatic Research Unit (CRU) of University of East Anglia.

Earth Observations

Sentinel-2a and 2b MSI



Landsat 8 OLI/9 OLI-2



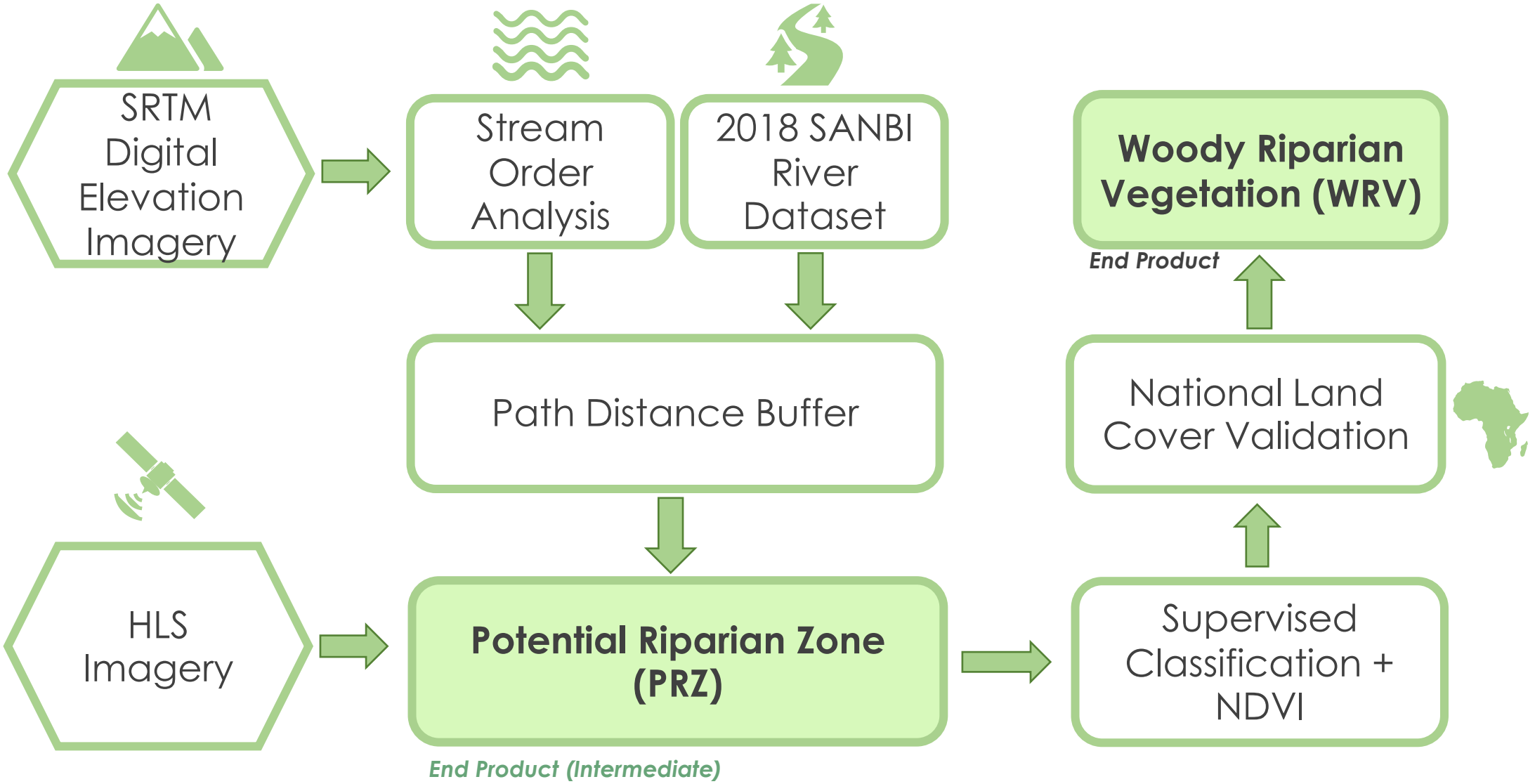
Shuttle Radar Topography Mission

Harmonized Landsat and Sentinel-2 Dataset (HLS)

(SRTM)

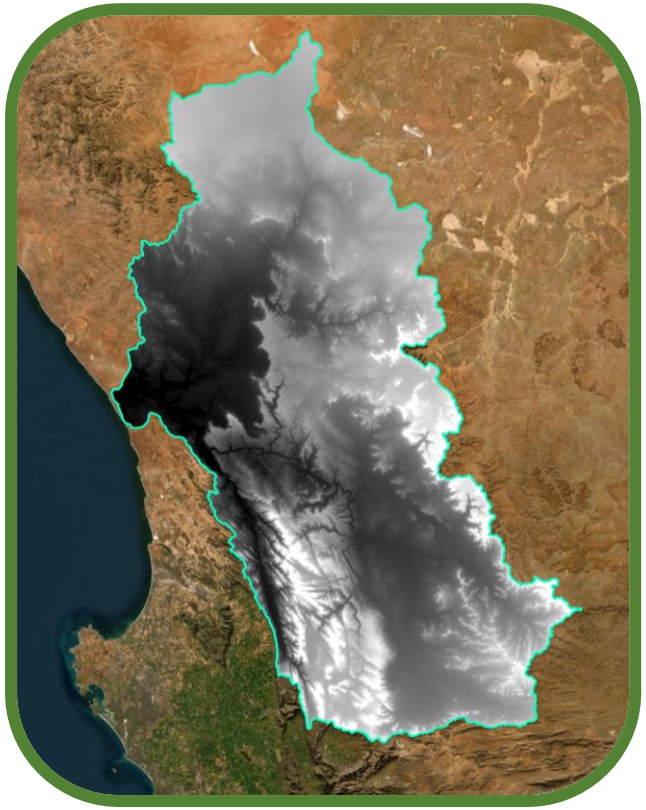
Image Credits: Rama, NASA

Methodology Overview



Methodology: Potential Riparian Zone Analysis

Methodology – Potential Riparian Zone



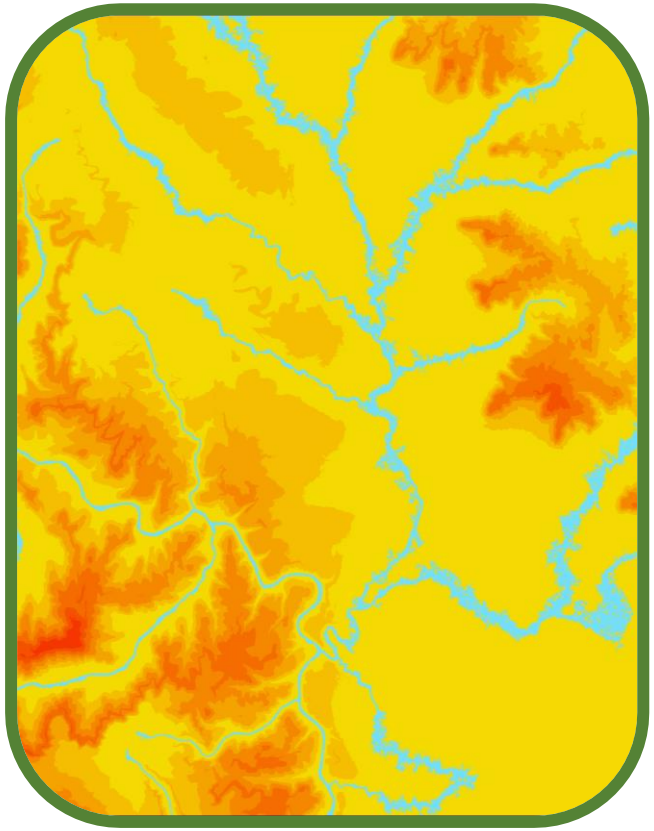
Mosaic SRTM DEM imagery and **clip** to region of interest

Perform a **Stream Order Analysis** to estimate river systems

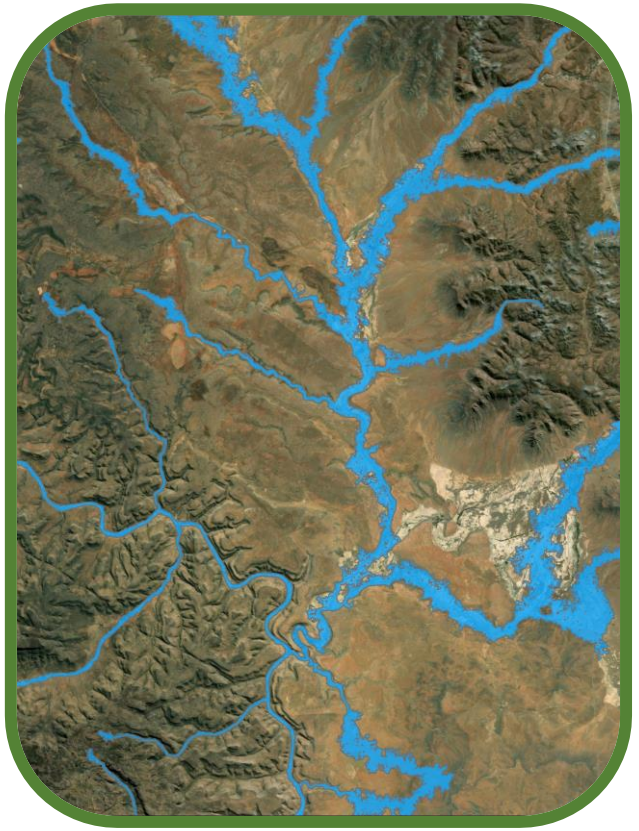
Create **buffer** based on Stream Order Analysis

Methodology – Potential Riparian Zone

Generate **Euclidian Distance** from the National Rivers Dataset

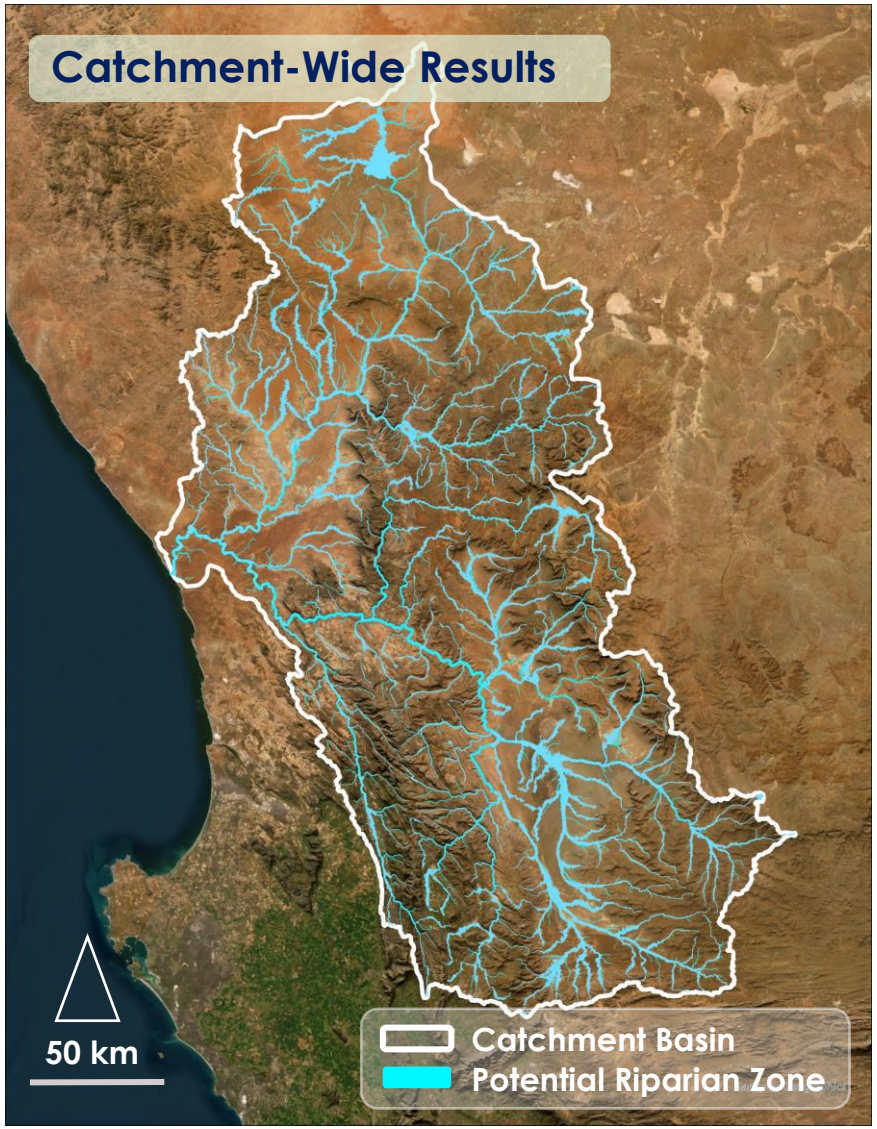


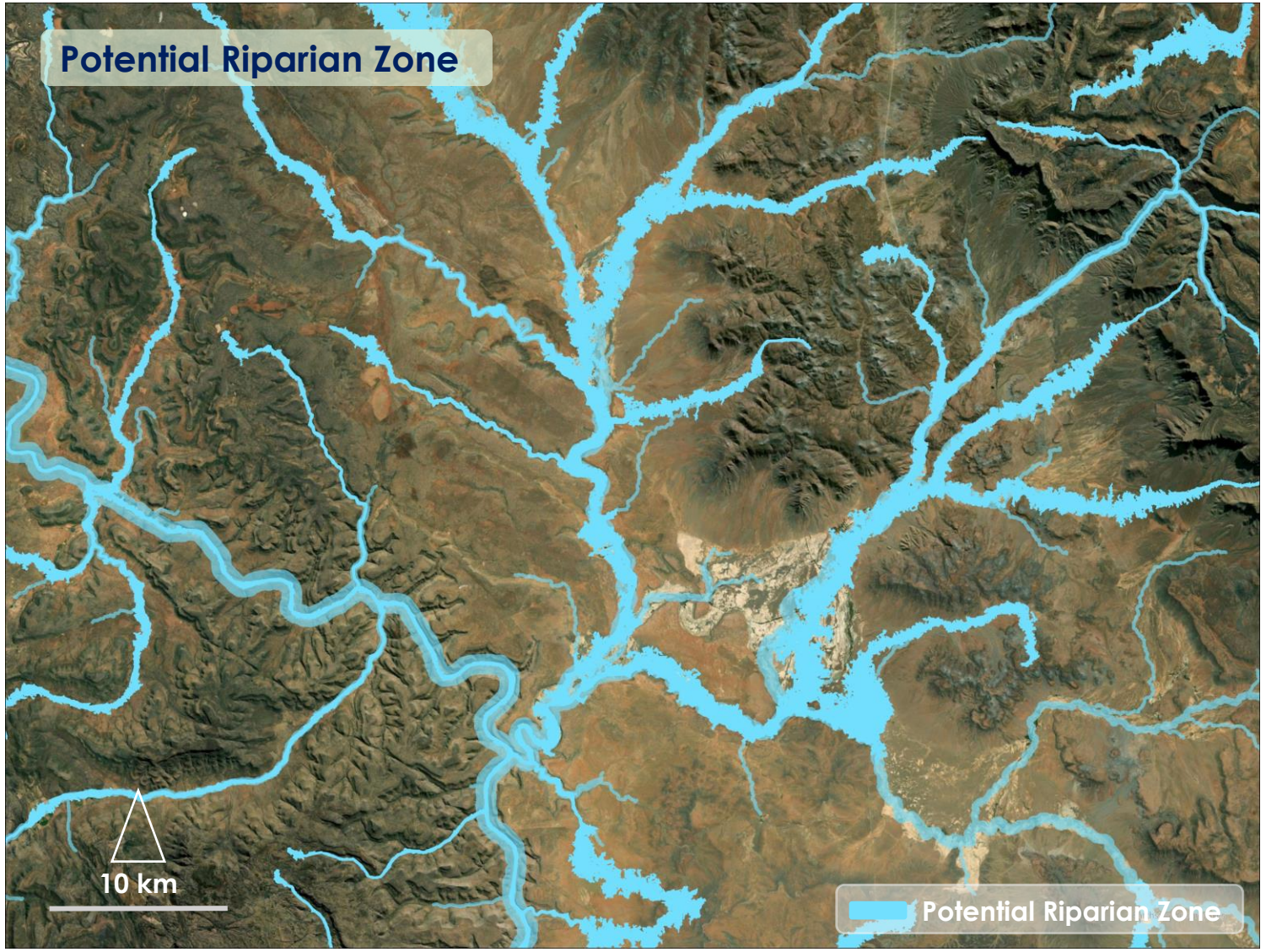
Use **Path Distance** tool on merged raster



Reclassification and **buffering**

Results – Potential Riparian Zone





Methodology: Calculating Woody Riparian Vegetation

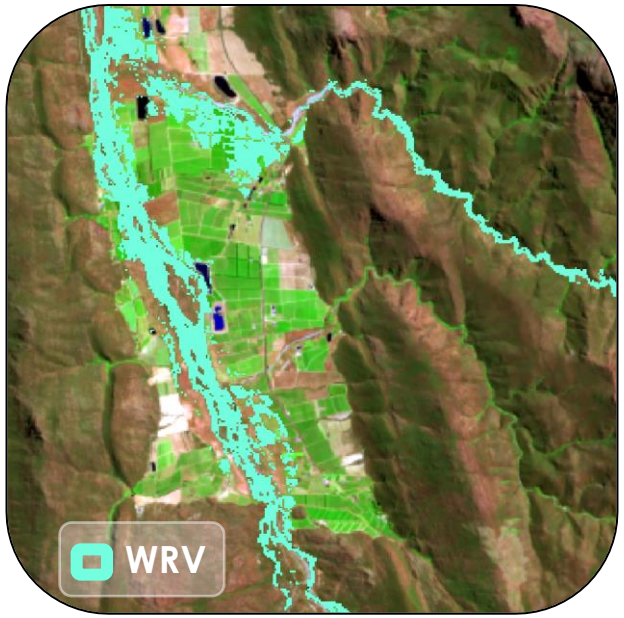
Methodology – Woody Riparian Vegetation

Generate a **composite raster** with shortwave infrared, near-infrared, and green bands to differentiate between water bodies and vegetation

Clip composite raster to the **potential riparian zone** for classification

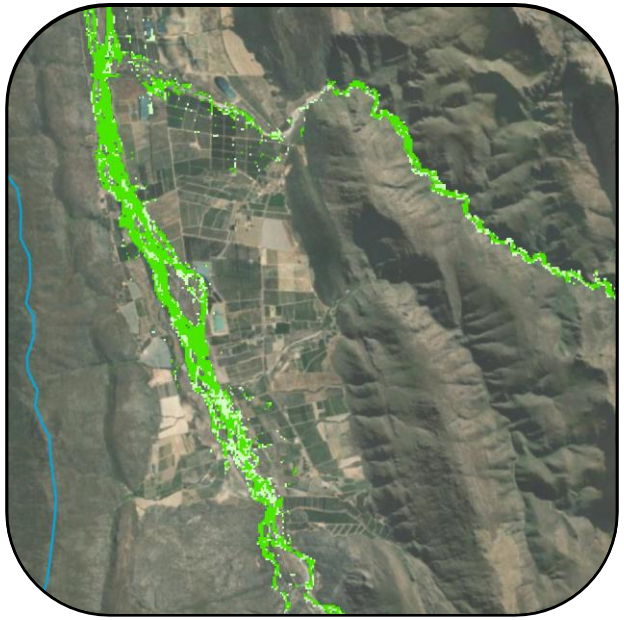
Create a **training sample** for woody and non-woody riparian areas

Methodology – Woody Riparian Vegetation



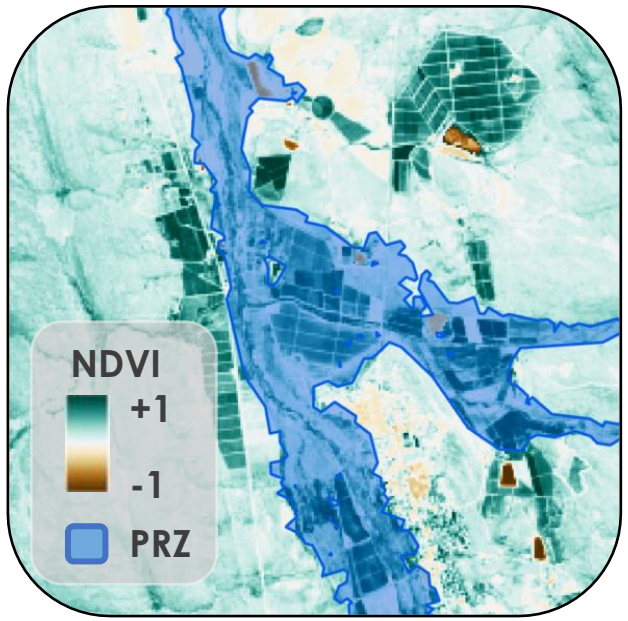
Classify woody riparian vegetation using **Random Forest** classification *training model accuracy = 0.9865*

Extract agricultural and urban areas from classified results

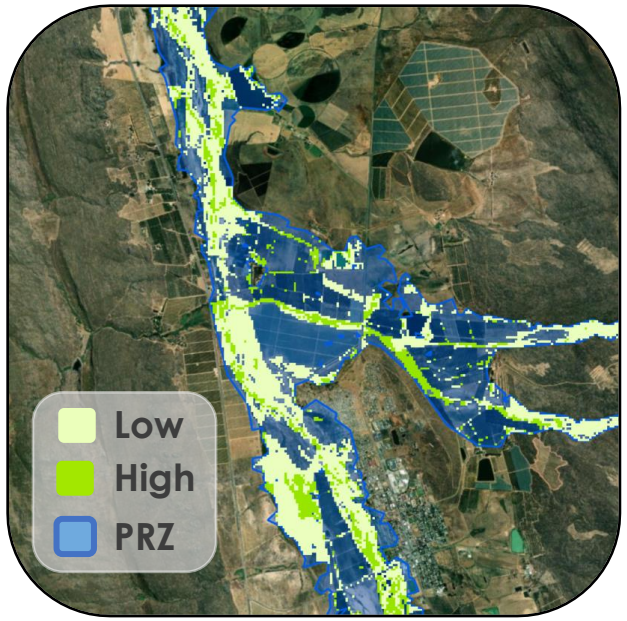


Intersect classification with a national land cover layer to determine "High Confidence" and "Low Confidence" riparian areas

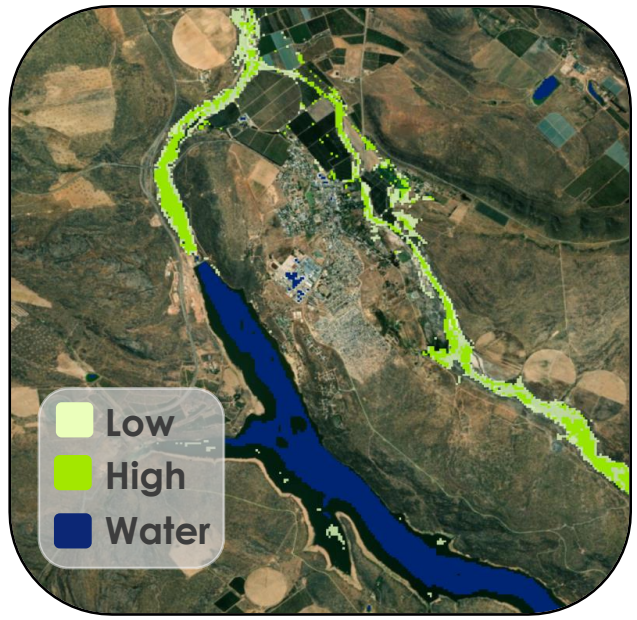
Simplified Methodology – NDVI + NDWI



Normalized Difference Vegetation Index (near-infrared and red bands)

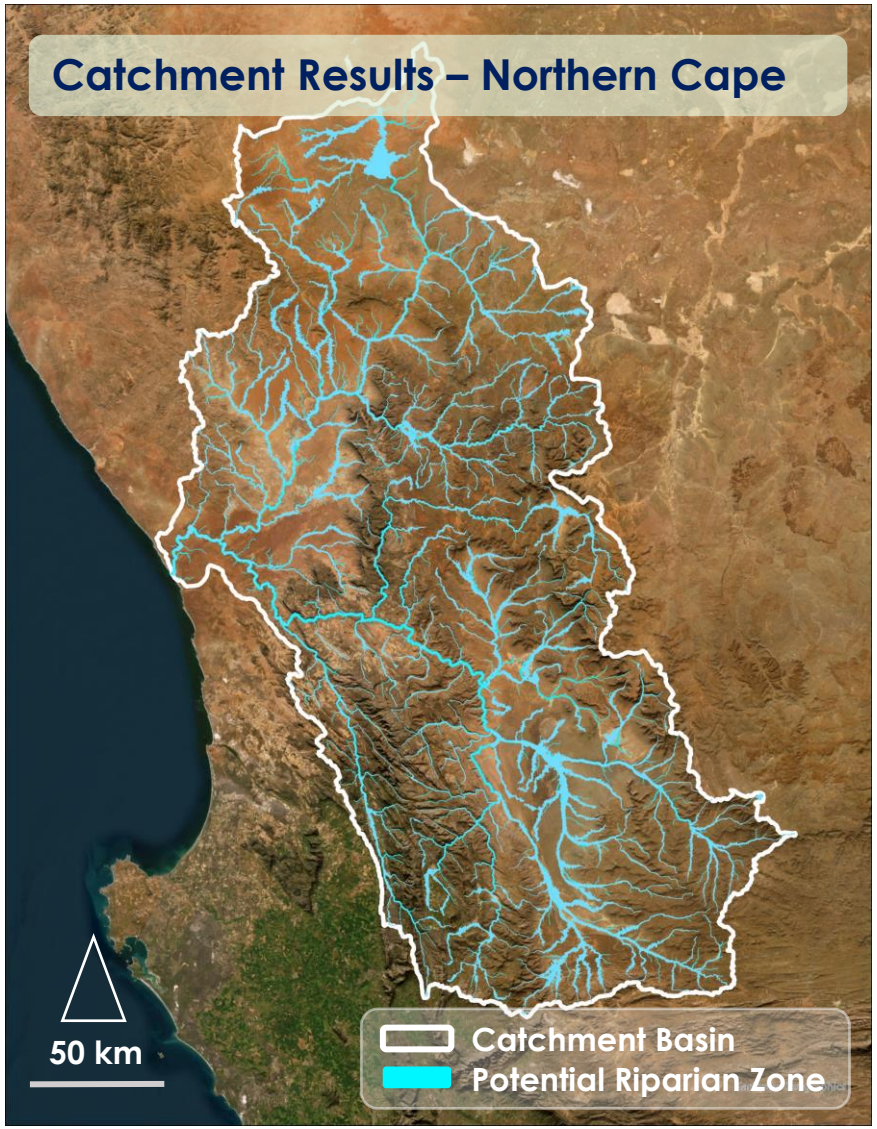


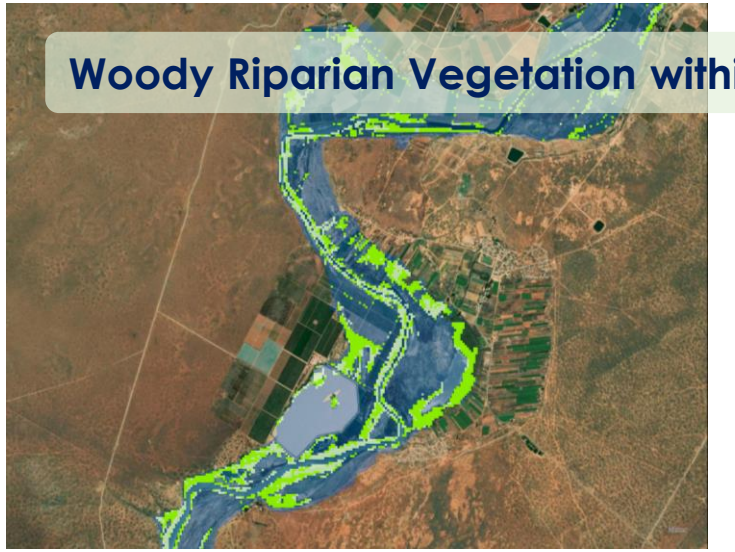
Reclassify **NDVI > 0.3** and determine "High Confidence" and "Low Confidence" riparian areas

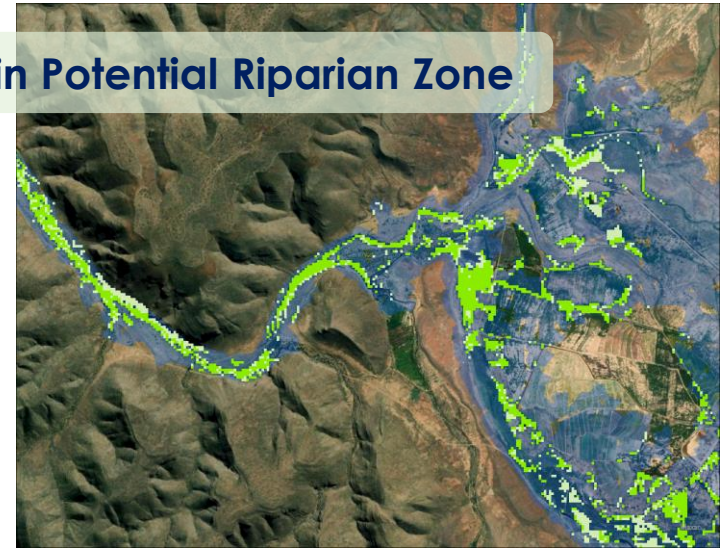


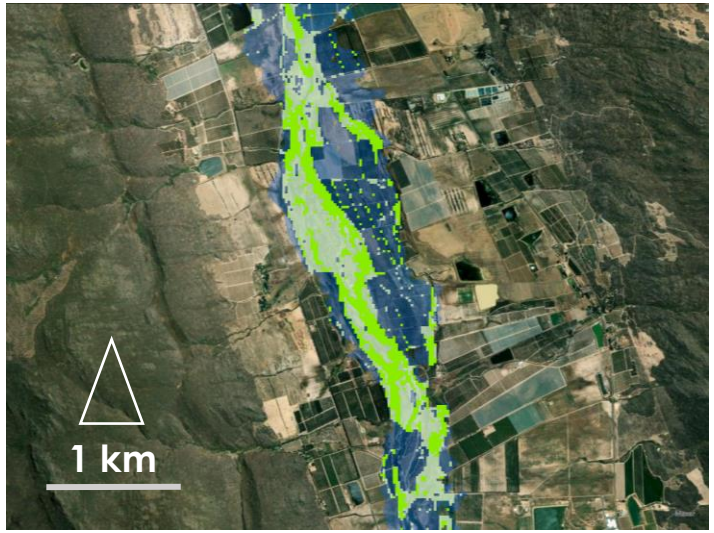
Normalized Difference Water Index to identify surface bodies

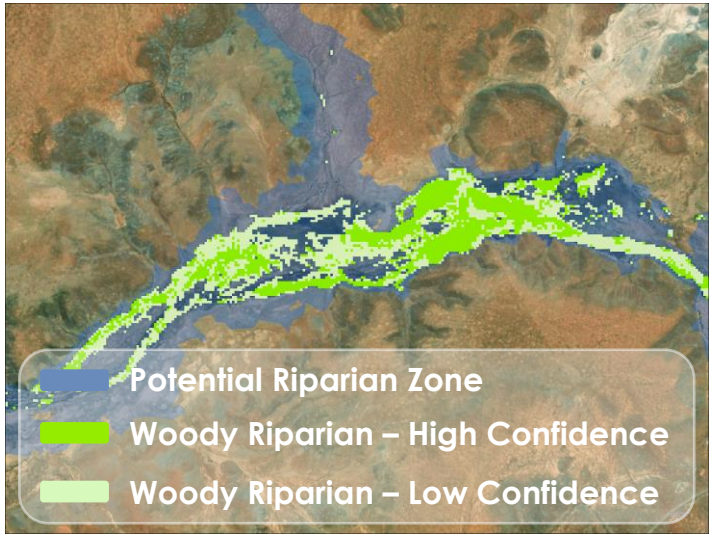
Results – Woody Riparian Vegetation









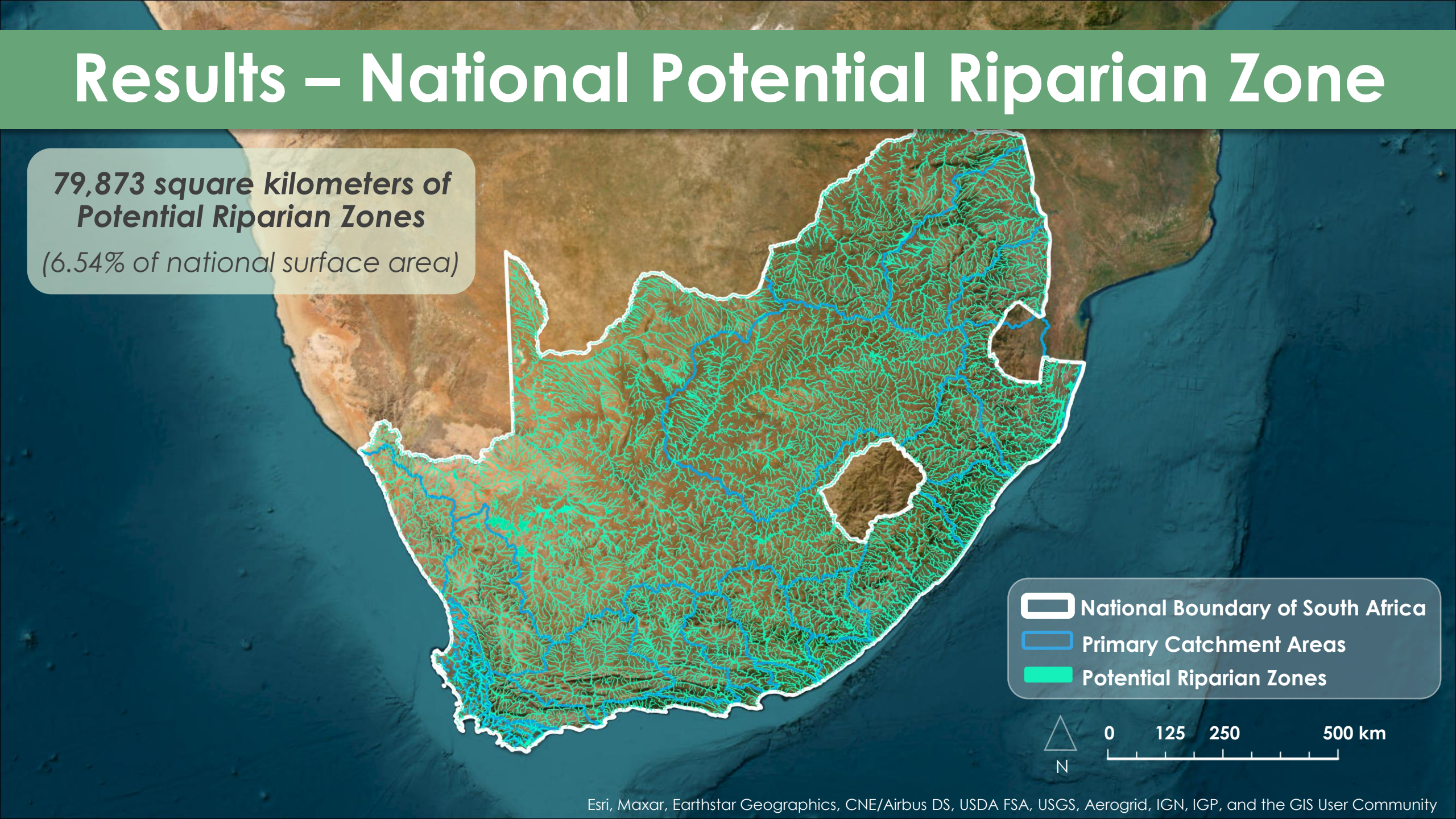


Esri, Maxar, Earthstar Geographics, CNE/Airbus DS, USDA FSA, USGS, Aerogrid, IGN, IGP, and the GIS User Community

Results – National Potential Riparian Zone

79,873 square kilometers of Potential Riparian Zones

(6.54% of national surface area)



Results – Data Analysis

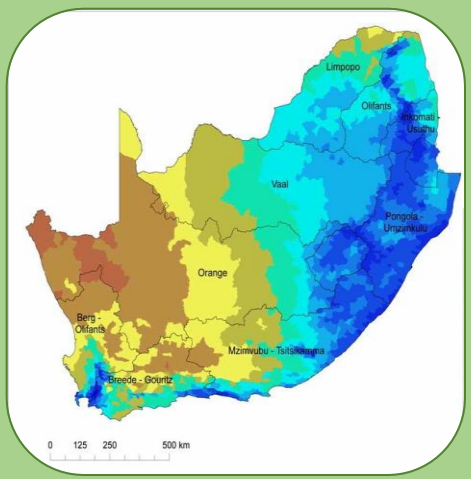
	Western Cape Province	National
Potential Riparian Zone	7,642 square kilometers **5.89 %** of the province surface area	79,873 square kilometers **6.54 %** of the national surface area
	Western Cape *(Basin E Testing Area near Northern Cape)*	***Western Cape*** *(Basin G Testing Area around Cape Town)*
Woody Riparian Vegetation (Total)	564 square kilometers **1.15 %** of the catchment area (49,065 square kilometers)	335 square kilometers **1.32 %** of the catchment area (25,298 square kilometers)
Woody Riparian Vegetation (High Confidence)	154 square kilometers **0.31 %** of the catchment area (49,065 square kilometers)	134 square kilometers **0.53 %** of the catchment area (25,298 square kilometers)

Errors and Uncertainties

Moderate HLS resolution (30m)

Stream order may capture streams that have been modified

Training based on satellite imagery; national land cover data used for ground truthing



Variability in rainfall between different regions

Conclusions

Methodology

Buffer and Classify Approach

Simplified NDVI Threshold Method

Effective detection of woody riparian vegetation

Changes to Methods

Temporal selection of imagery

HLS Data (30m)

Supervised Classification ✓

Resolution and representative month effective to map woody riparian vegetation

Key Findings

Potential riparian zones identified

79,873 square kilometers (**6.5%** of national surface area)

1.15 % of catchment area is woody riparian vegetation (training done in select catchments)

Partner Implementation

The geospatial products created in this project will provide SANBI with invaluable data on riparian zones, allowing them to:

Prioritize conservation and restoration of riparian ecosystems based on the identified high confidence woody riparian vegetation	Monitor changes in riparian vegetation over time by comparing the current woody riparian vegetation to future updates	Integrate the comprehensive woody riparian vegetation dataset into SANBI's biodiversity planning and decision-making processes to better protect riparian habitats and the species they support

Acknowledgments

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- Dr. Arnaud Cerbelaud (NASA Jet Propulsion Laboratory, Caltech)
- Ben Holt (NASA Jet Propulsion Laboratory, Caltech)

Partners

- Anisha Dayaram (SANBI – Vegetation Scientist)
- Nancy Job (SANBI – Freshwater Team Lead)

Center Lead

- Michael Pazmino (NASA DEVELOP, California – JPL)

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- *Madison Elowitt*
- *Katya Beener*
- *Andrew Saah*

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