National Aeronautics and
Space Administration

COSTA RICA WATER RESOURCES

Monitoring Drought and Water Balance in the Guanacaste Province to Enhance Decision Making and Response Planning in Costa Rica

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Study Area & Period

- Guanacaste Province, Costa Rica
- 20% of Costa Rica's hydroelectric power comes from the Arenal Reservoir
- Predominance of sugarcane, and rice agriculture
- Great variety of life zones, biodiversity, and climate
- Study period: January 2000 to March 2016

Community Concerns

Photo Credit: Official webpage Presidency of the Republic of Costa Rica

- Four consecutive years of drought
- Estimated $25 million economic loss in agricultural production
- Drinking water shortage to the local community
- Demand on available water resources for all uses in Costa Rica will increase from 5% to 35% until 2020

Objectives

Image Credit: Javier Artinano, SENARA

Develop a time series for the meteorological and agricultural drought indices for the study area

Create a near-real time drought monitoring tool for the Arenal-Tempisque watershed for partners to utilize in the future

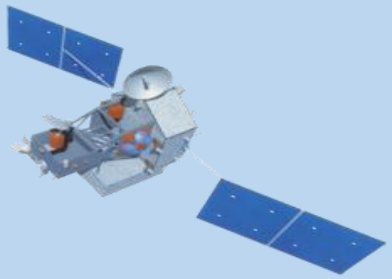
Analyze local water systems using ArcSWAT to produce results that will be incorporated into a water balance assessment toolset

Earth Observations and Parameters

Precipitation

Tropical **R**ainfall **M**easuring **M**ission – **P**recipitation **R**adar

(**TRMM-PR**)

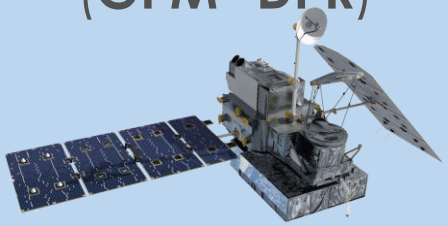


January 2000 - March 2016

Precipitation

Global **P**recipitation **M**easurement – **D**ual-frequency **P**recipitation **R**adar

(**GPM- DPR**)



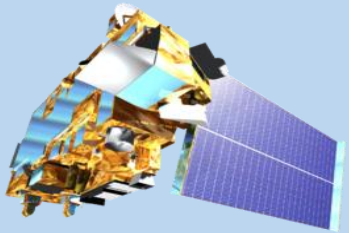
April 2015 - Present

LST, NDVI

Terra

MODerate **R**esolution **I**maging **S**pectroradiometer

(MODIS)



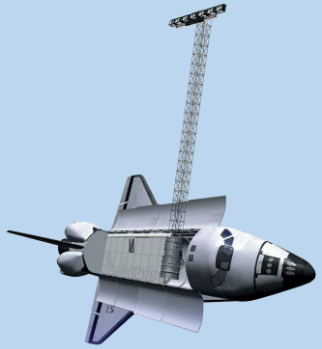
March 2000-March 2016

Earth Observations and Parameters

Digital Elevation Models

Shuttle **R**adar **T**opography **M**ission

(SRTM)



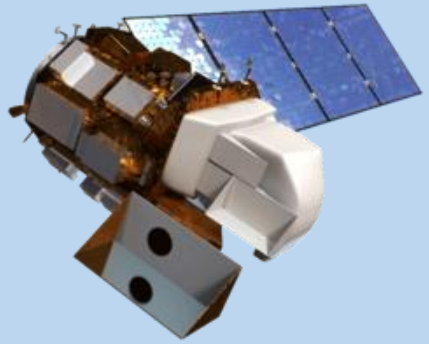
February 2000

Surface Reflectance

Landsat 8

Operational **L**and **I**mager

(OLI)

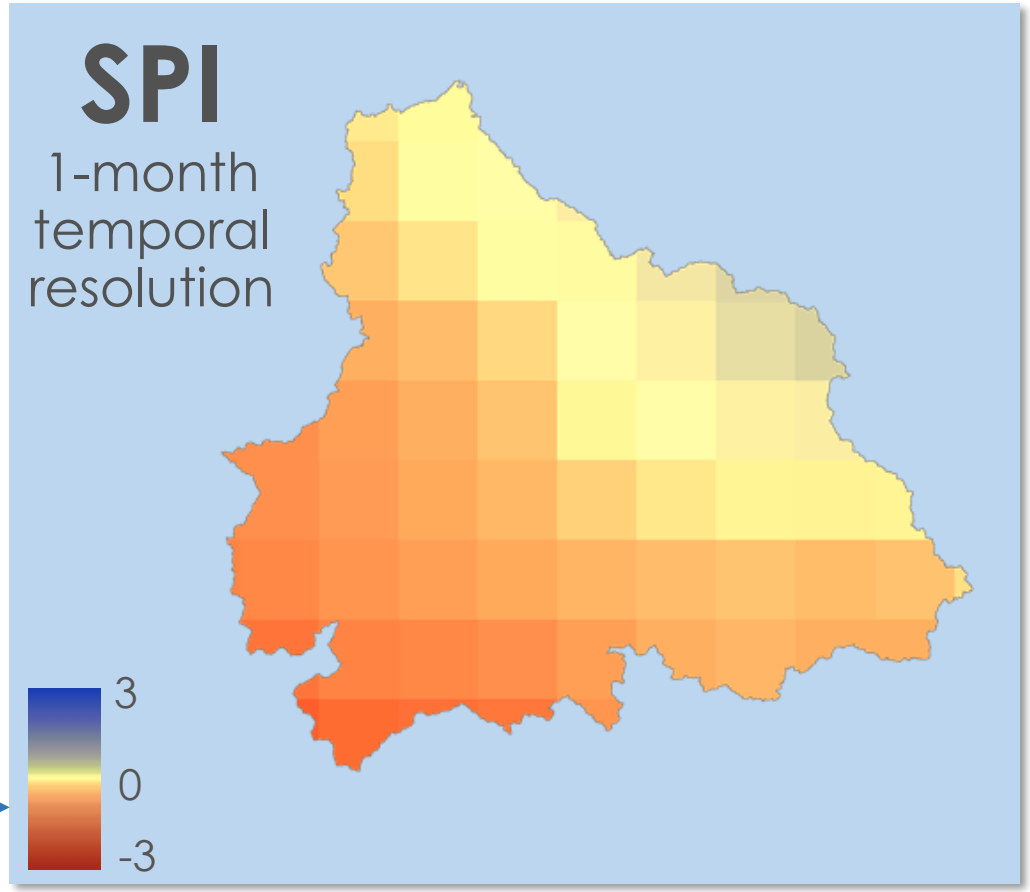


April 2013

Standardized Precipitation Index (SPI)

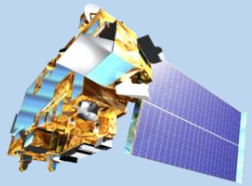
Meteorological Drought Time Series

SPI Value	Interpretation
≥ 2.0	extreme wet condition
1.5 to 1.99	severe wet condition
1.0 to 1.49	moderate wet condition
0.5 to 0.99	mild wet condition
-0.49 to 0.49	optimum rainfall
-0.5 to -0.99	mild drought condition
-1.0 to -1.49	moderate drought condition
-1.5 to -1.99	severe drought condition
≤ -2.0	extreme drought condition



Scaled Drought Condition Index (SDCI)

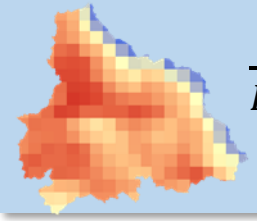
Agricultural Drought Time Series



Terra MODIS
Monthly average LST, NDVI
0.1° & 0.05°-Spatial Resolution
Level 3 Product

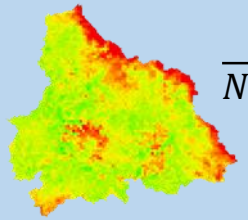
TRMM-PR
Monthly precipitation (mm)
0.25°-Spatial Resolution
3B42 Level 3 product

LST



$$\frac{LST_{max} - LST}{LST_{max} - LST_{min}}$$

NDVI



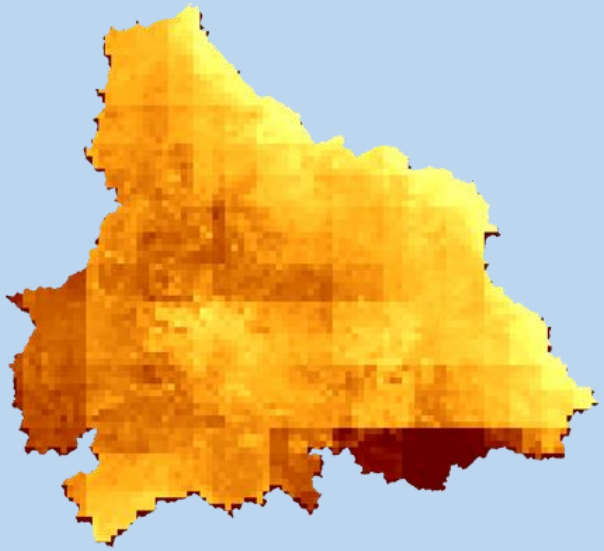
$$\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$$

Precipitation

$$\frac{X - X_{min}}{X_{max} - X_{min}}$$

SDCI

1-month temporal resolution



SDCI = (0.25 *Scaled LST)
+ (0.25* Scaled NDVI)
+ (0.5 * Scaled Precip)

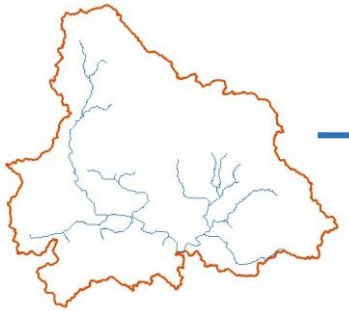
ArcSWAT Inputs

DEM

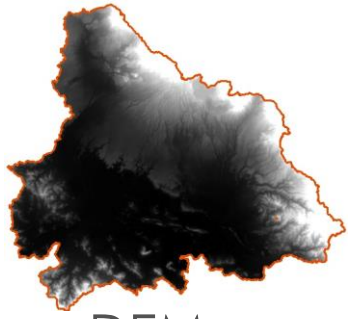
Land Cover

Soil

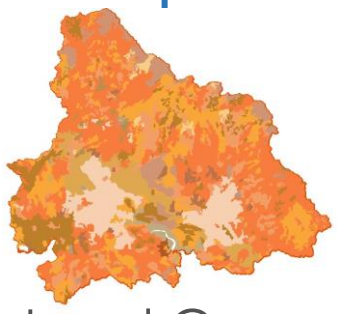
Watershed Delineation



Reclassification



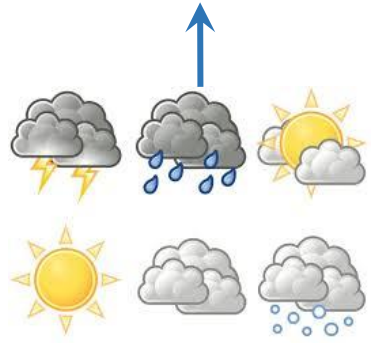
DEM



Land Cover

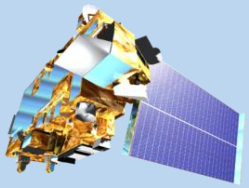
Soil

Run SWAT Model

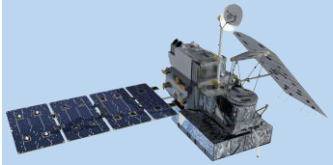


Weather

Near-Real Time Monitoring Tool



Terra MODIS
Monthly average LST, NDVI
0.1° & 0.05°-Spatial Resolution
Level 3 Product



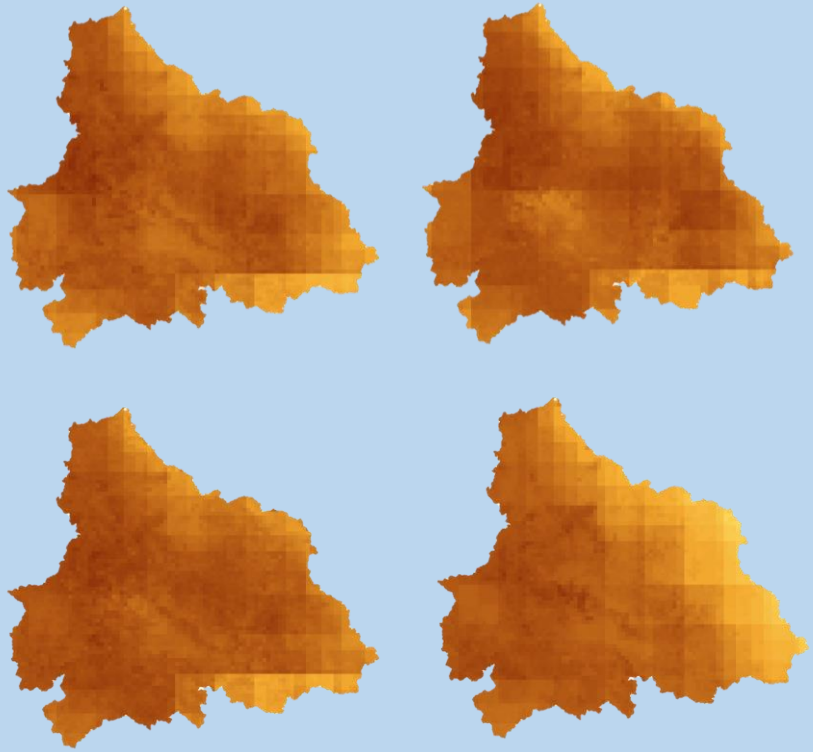
GPM IMERG
Daily Precipitation
0.1° -Spatial Resolution
Level 3 Product

Daily → Monthly

Python Script

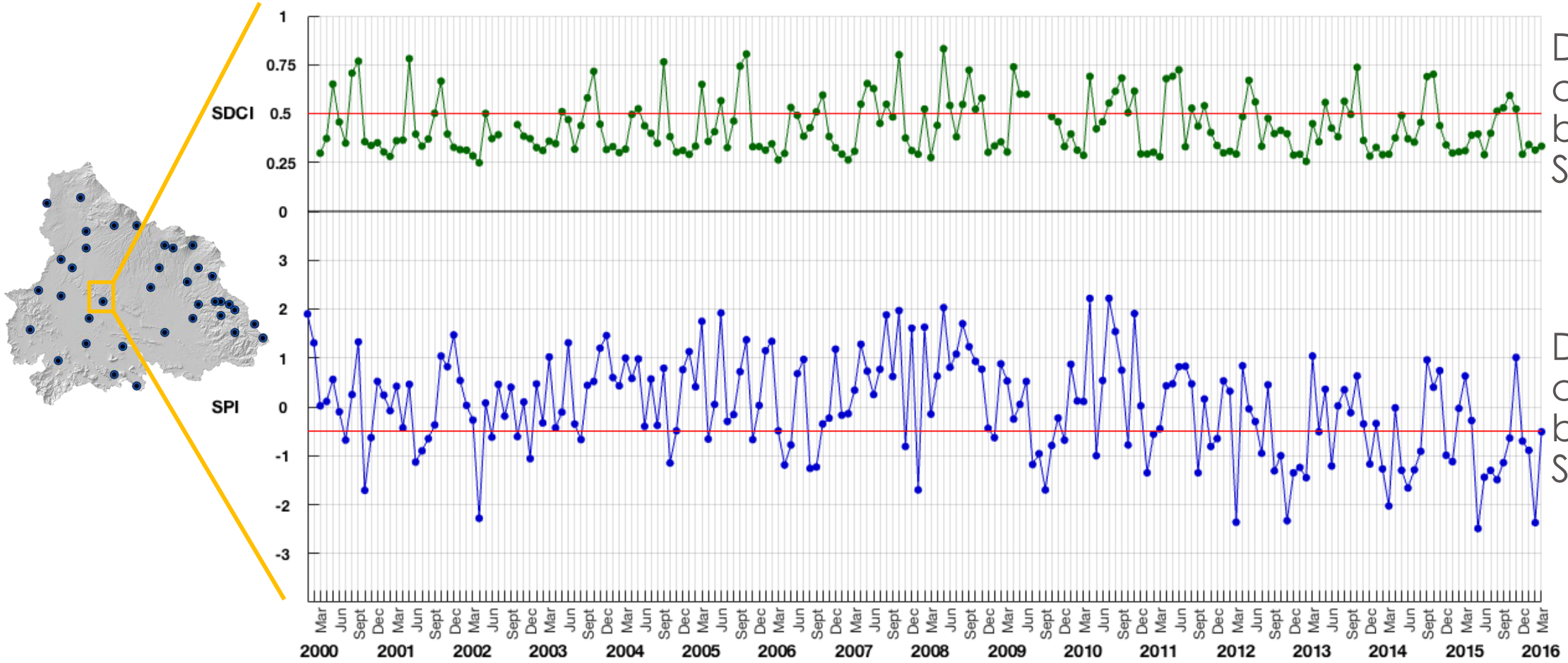
SDCI Rasters

1-month temporal resolution



Results and Discussion

Monthly Drought Indices for Estación de Pelon de La Bajura Guanacaste Province: January 2000 - March 2016



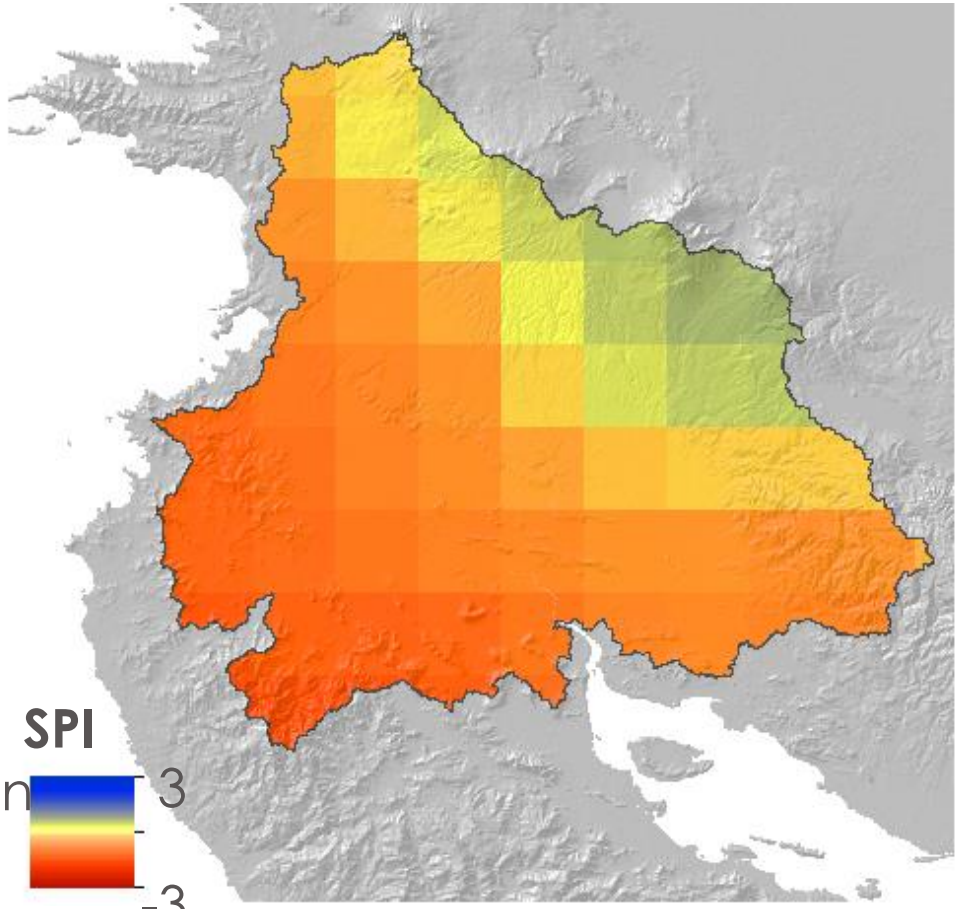
Drought condition begins when SDCI ≤ 0.5

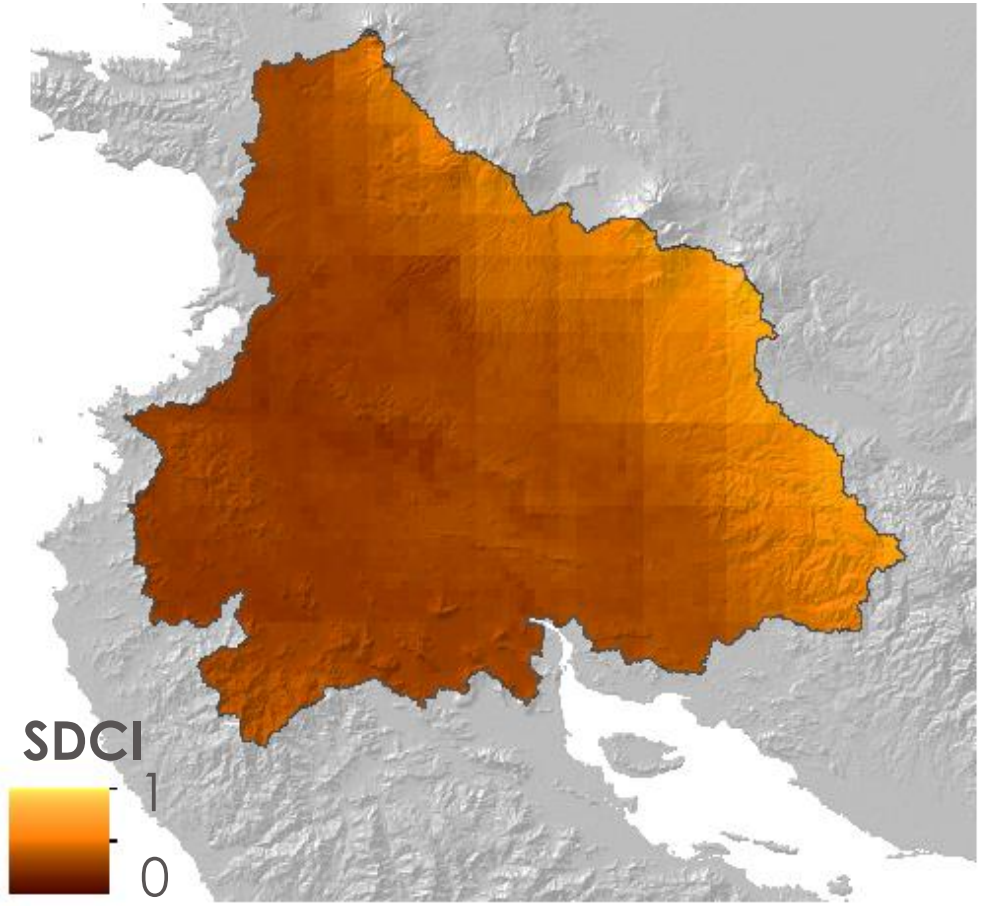
Drought condition begins when SPI ≤ -0.5

Results and Discussion

Drought Anomaly in December 2015

Drought condition begins when SPI ≤ -0.5

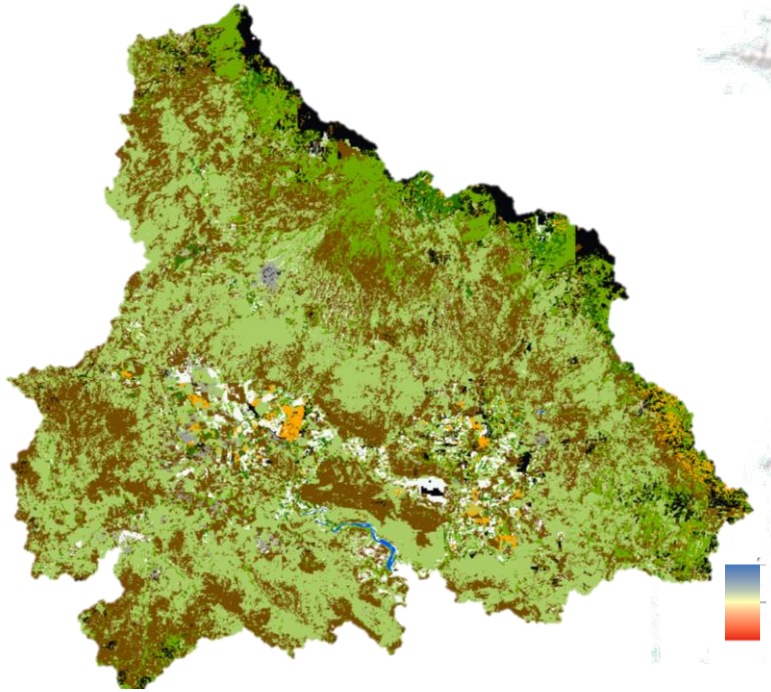




Drought condition begins when SDCI ≤ 0.5

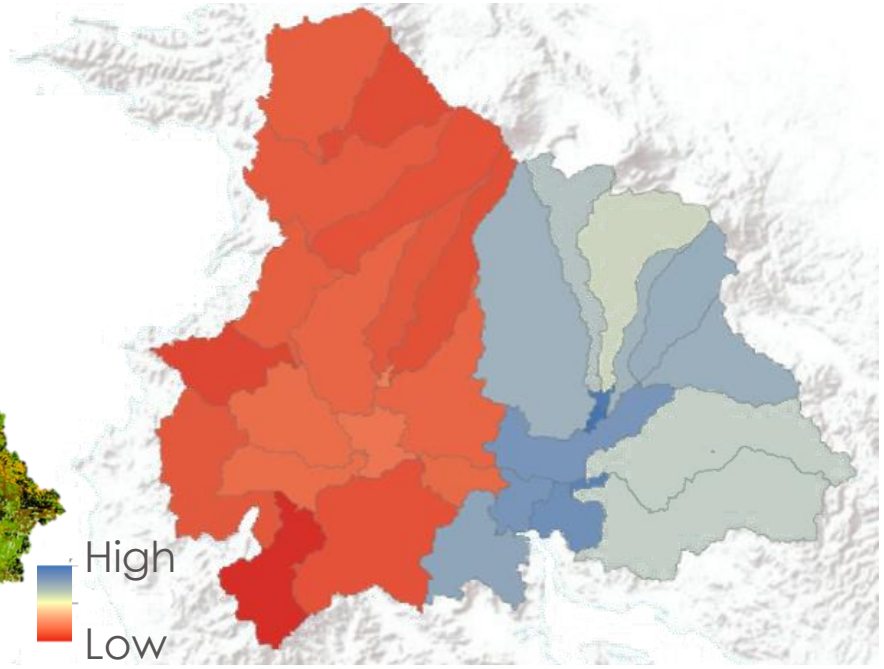
ArcSWAT Results and Discussion

Land Cover
Supervised Classification

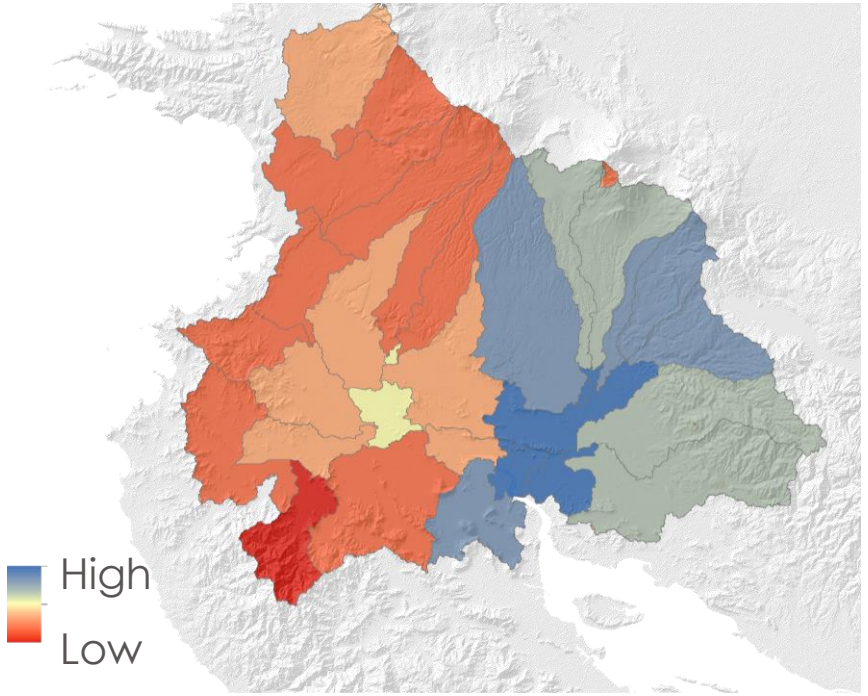


Unclassified
Forest - Evergreen
Forest - Mixed
Rice
Sugarcane
Water Body
Grass
Brush
Rural/Residential

Superficial Flow
Identified by the SWAT model



Evapotranspiration Rates
Identified by the SWAT model



Limitations


Image Credit: Javier Artinano, SENARA

- Lack of in-situ, streamflow measurements
- SWAT results are not calibrated
- Only fourteen years of meteorological information measured in the study area
- Weather station data inconsistent both by type and temporally

Outcome and Benefits


Image Credit: Javier Artinano, SENARA

Data for monthly SDCI and SPI values for 38 weather stations in the Arenal-Tempisque watershed

Updated Land Cover data for future use

SWAT manual for partners for watershed modeling

Working script for near-real SDCI monitoring tool

Better decision-support tools to enhance mitigation of the negative impacts caused by drought

Future Research


Image Credit: Javier Artinano, SENARA

- Use streamflow in situ data to run SWAT-CUP and calibrate SWAT results
- Complete SDCI near-real time monitoring tool for future use by partners
- Additional drought indices can be used to produce more detailed spatial and temporal analyses
- ArcSWAT outputs can be further studied to understand hydrology of the area

Acknowledgements

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