DSET Application Case Study: Agriculture

Please refer to the primary User Guide document for a general overview of the Navajo Nation Drought Severity Evaluation Tool (DSET) and a complete list of case study examples (including drought, wildfire, snowpack, and downloading data). If you are only interested in the agriculture case-study example, you can use this document.

Introduction

On the Navajo Nation, enterprises such as the Navajo Agriculture Products Industry (NAPI) have been established to continue in the legacy of Navajo farming. NAPI has a large agricultural production region near Farmington, New Mexico. Agriculture in semi-arid to arid regions is vulnerable to drought. Large scale agricultural enterprises rely on dependable water access for the health of their crops. The consistency of water access provides greater chances of a successful harvest. Agricultural droughts occur when available water supplies are not able to meet crop water demands. Although this crop analysis case study will be focused on NAPI, similar assessments can be established for other known agriculture areas on the Navajo Nation and can be assessed on an Agency and Chapter House boundary level through the use of the Drought Severity Evaluation Tool (DSET).

DSET can help in understanding crop health through the use of drought and vegetation indices related to agricultural drought. Indices and climate variables such as the Normalized Difference Vegetation Index (NDVI), precipitation, and evapotranspiration (ET) can help in assessing crop health. The NDVI is a measure of vegetation vigor or health though the use of a ratio of the reflection of red and near-infrared wavelengths. Healthy vegetation reflects green wavelengths (this is why we see most healthy plants as green) and strongly reflects near-infrared wavelengths. Therefore, the greater the NDVI value, the healthier the plant. Lower NDVI values indicate less healthy vegetation. Declines in precipitation also impacts the growth and productivity of vegetation.

Components of Analysis

- Datasets: Landsat 4/5/7/8 Surface Reflectance and Climate Hazards Group InfraRed Precipitation with Station (CHIRPS)
- Variables: Normalized Difference Vegetation Index (NDVI) and Precipitation (PPT)

Objectives

- Use the Last Northern Growing Season (Apr – Oct) for this example 2019-04-01 to 2019-10-31 to calculate the NDVI value.
- Use the calculated NDVI value to create a time series for a NAPI crop plot for the past 20 years.

- Use CHIRPS –Pentad PPT measurements and NDVI values of a NAPI crop plot to see the influences of drought and irrigation on agricultural production.

Helpful Tips

- DSET is optimized for Google Chrome, please use Chrome.
- Faster networks are preferred when using DSET.
- Zoom to area of interest before submitting map requests to help with re-computing data.
- Resubmission and reset of DSET can help with fail requests that produce a server error.
- The figures included in this case study will help you navigate the DSET to locate the features associated with each step. It is suggested that you use the figure to ensure your selections are correct prior to completing each major step within the exercise.
- In the case study exercise, a color-coding system is used to help with navigation of the DSET features. For example, the section heading **Visualization Layer**, matches the color of the wording you will find on the DSET webpage.

Estimated Time for Completion for the Crop Analysis Case Study: **33 Minutes**

This exercise for Case Study 2: Crop Analysis is broken up into two sections. The first section is Part 1: NDVI Crop Analysis for the Last Northern Growing Season and the second is Part 2: NAPI Field Data Time Series.

Part 1: Crop Analysis for the Last Northern Growing Season

- Objective: Use the Last Northern Growing Season (Apr-Oct) for this example those dates are 2019-04-01 to 2019-10-31 to calculate the NDVI value.

NDVI uses the ratio of reflection of red and near-infrared wavelengths to measure vegetation health. The equation for calculating the NDVI values using the red and near-infrared wavelengths is $NDVI = \frac{(NIR)-(Red)}{(NIR)+(Red)}$. The scale values for NDVI range from +1.0 to -1.0. A high NDVI value is an indicator of an area with dense vegetation. In this exercise a higher NDVI value represents NAPI crops at their peak growth state.

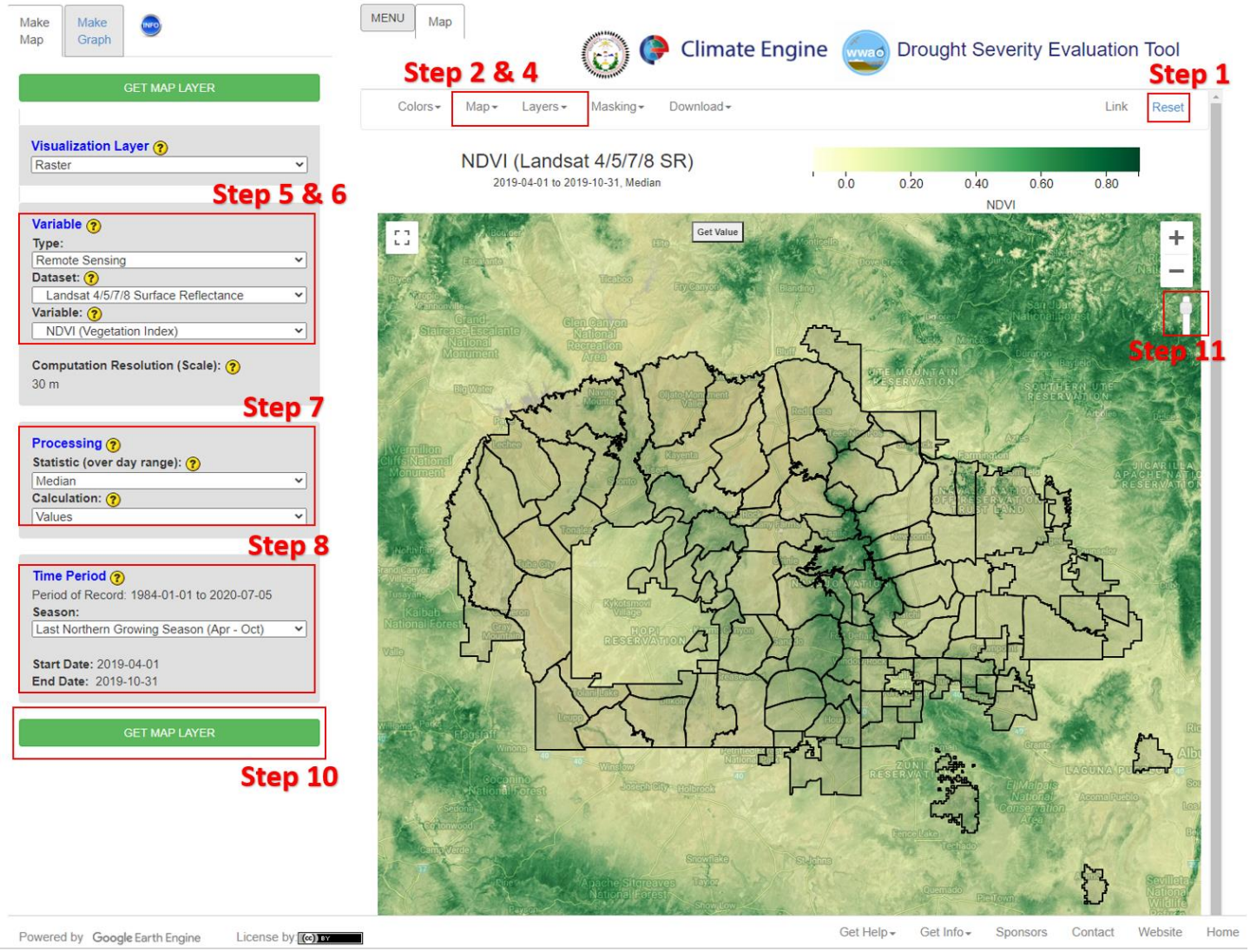


Figure 1. The darkest green colors represent the crops with the highest amounts of chlorophyll, thus displaying a high NDVI value. Some of the crops with lighter green may be less green, or not as heavily irrigated. The darker the shade of green is representative of the greater density of vegetation. Guidance for steps 11 through 18 are indicated in this figure.

1. Go to the DSET website using this link https://app.climateengine.org/dset.
    a. If you are conducting this Case Study for Crop Analysis after working on Case Study 1, at the top right corner of the map, click **Reset**.

2. Under the **Layers** tab along the top, ensure that the **Navajo Nation Chapters** boundary is selected and displayed on the map.
    a. Note: The Navajo Nation Chapter boundaries should appear as the default.
3. Zoom into the Navajo Nation reservation boundary using the "+" sign along the top right.
4. Click on the **Map** tab along the top, which hosts the map options, and select the **Hybrid map**.
    a. Note: The Hybrid map should appear as the default.
5. Located on the Make Map panel on the left side of the webpage, under the **Variable** section select the **Type** parameter to be **Remote Sensing**, and change the **Dataset** parameter to **Landsat 4/5/7/8 Surface Reflectance.**
6. For the **Variable** select **NDVI (Vegetation Index)** located under the **Vegetation Indices Section.**
    a. Note: The Landsat 4/5/7/8 Surface reflectance and the NDVI (Vegetation Index) should appear as the default when Remote Sensing is selected as the Variable.
7. Under the **Processing** section select the **Statistic (over day range)** to be **Median**, leave the **Calculation** to be set on **Values**.
8. Under the **Time Period** section located on the same panel, select the **Last Northern Growing Season (Apr – Oct).**
    a. Selecting the **Last Northern Growing Season (Apr – Oct)** will change the start date to **2019-04-01** and end date to **2019-10-31**. These dates will appear if this exercise is done in 2020. After 2020, the **Last Northern Growing Season (Apr – Oct)** dates will change to show the most recent growing season**.** For example, if this exercise is done in the year 2021 (before October) the dates for the Last Northern Growing Season (Apr – Oct) will have the start date 2020-04-01and the end date of 2020-10-31.
9. Leave all other options on the panel as default.
10. Click on **Get Map Layer**, wait for the map to load. The loading of the map may take a few minutes for the request to process.
11. Once the processing is complete, the map will automatically display the data. The **transparency** may be decreased or enhanced to better see the results. On the top right of the map, move the opacity slider 

down to 70% Opaque.
12. Your map should look like Figure 1 (above).
13. To get more information about the **NDVI (Vegetation Index)**, click on the yellow arrow next to **Variable**.
    a. If you select the a pop-up box of the **Metrics** will appear and will have to be closed manually by clicking the **x** at the top right corner of the pop-up box.
14. **Do not Reset**. The same findings for the NDVI will be used in Part 2 of this Crop Analysis Case Study.

After creating an NDVI map for the Navajo Nation to analyze for the Last Northern Growing Season (Figure 1). It is evident where areas of dense vegetation exist based on the type of landscape. For example the Chuska Mountains are the dark green color near the center of the N.N. This is due to the high amount of chlorophyll in the vegetation present for a mountainous region. However, for areas in lower elevation on the Navajo Nation the NDVI values are less and are shown to be a light green color, where there is less dense vegetation. In the northeast corner of the reservation, you can see the NAPI fields located near Farmington, New Mexico. The darker shade of green shown for NAPI represents a greater density of vegetation in comparison to surrounding areas. Part 2 of this exercise will look more into the NDVI values of the NAPI center-pivot fields.

Part 2: Field Data Time Series

- Objective: Use the calculated NDVI values to create a time series for a NAPI field for the past 20 years.

Now in Part 2 the development of a data time series for a specific field is the goal. The data time series will show the characteristics of the NAPI fields. The characteristics that will be shown are the crop cycles and the influence of drought and irrigation on the crop outputs.

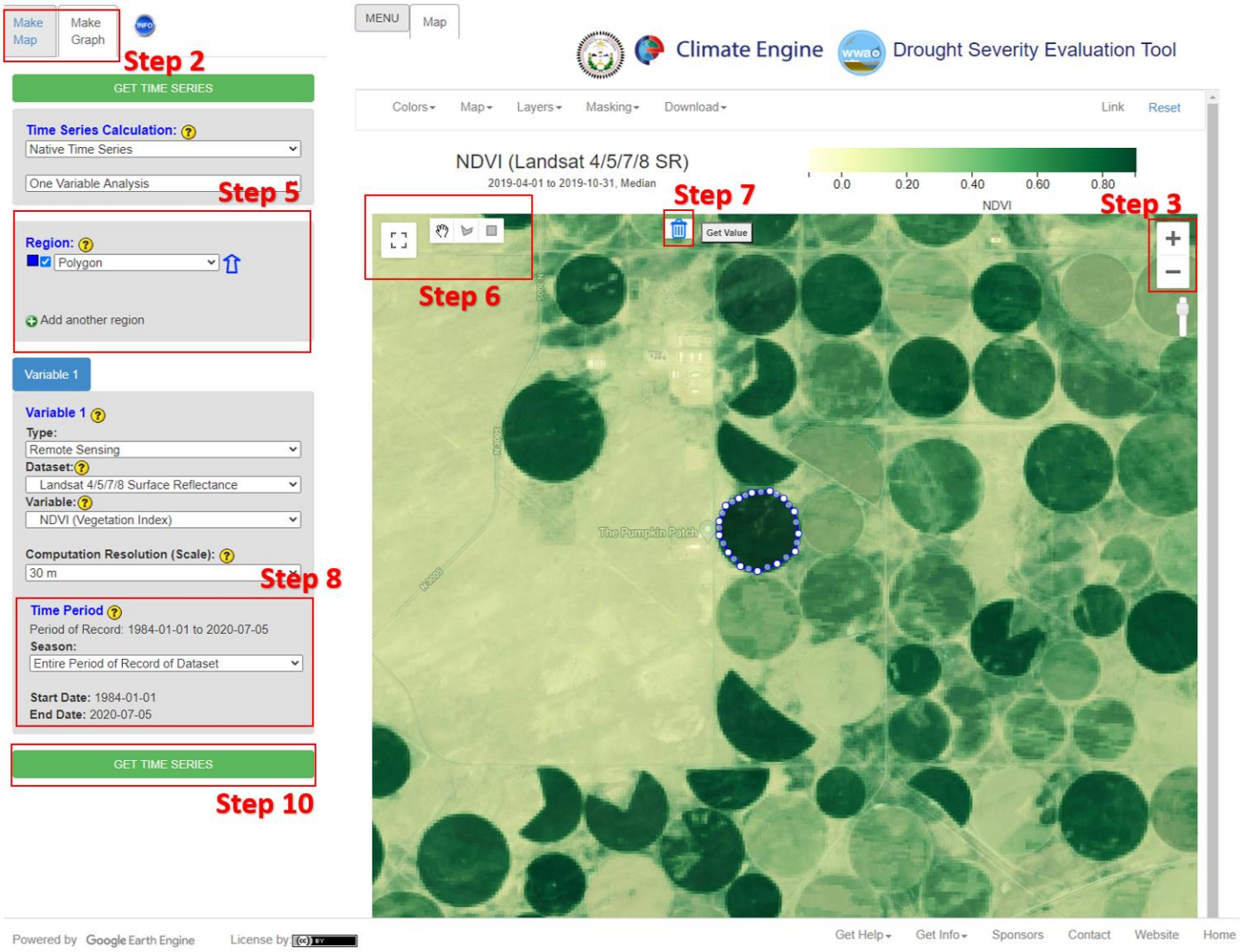
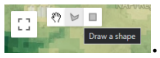


Figure 2. Specific NAPI center-pivot irrigation field near The Pumpkin Patch. This field selected as indicated by the dots encircling the field is used to provide a data time series for the values of NDVI found at this location from 1984-01-01 to 2020-07-05, the Entire Period of Record of Dataset. Guidance for steps 2 through 10 are shown in this figure.

1. Leave the **Make Map** panel as is from Part 1 of this Case Study.
2. Click on **Map Graph** tab beside the **Make Map** tab along the top left section of the DSET home screen.
3. Zoom into the Navajo Nation Chapter Boundary for Upper Fruitland, New Mexico located near Farmington, New Mexico using the "+" sign along the top right.
    a. The Upper Fruitland boundary will show NAPI fields.
4. Zoom in even closer to one specific center-pivot irrigation field that you want to analyze. For this exercise a center-pivot irrigation field near *The Pumpkin Patch* was identified.
5. Under **Region** in the panel on the left, select **Polygon** under the **Custom Polygon Regions**.
    a. Note that when you do this a pop-up will appear that describes **How to**

create a polygon how. Reading through this pop-up will help in making a polygon.

6. Close the pop-up and click on the **Draw a Shape** icon  in the top left of the map  .
    a. Note that when you do this, a cross-hair symbol will appear as your cursor.
7. Click on the outer edge of one of the crop circles to start to draw your circle. Multiple clicks will be needed to enclose the circle field. Keep clicking all the way around the circle. To close the circle, click the first dot in the circle.
    a. Once you have closed the circle the polygon will flicker and then will appear as a darker shade on the map.
    b. If you are unhappy with the circle around the field, you have the option to re-draw the crop circle. Use the delete button next to the Get Value button at the top of the map  .
8. Once you are happy with the polygon, change the **Time Period** section to have the **Season** select the **Entire Period of Record of Dataset**.
    a. Note that for this exercise the Entire Period of Record of Dataset includes the start date of 1984-01-01 and the end date of 2020-07-05. Depending on when this exercise is conducted the end date will vary to include the Entire Period of Record of Dataset up until when this exercise is being completed by the user.
9. The **Variable 1** section can be left as is with the selected **Type, Dataset, and Variable**.
10. Click on **Get Time Series** and wait for your figure to load.
    a. Again, if your time series does not appear after a few minutes you may have to **Reset** DSET again and run the analysis. Due to the large amount of data loading for the entire period of record, the figure may time a few minutes to load. If needed, you could choose a shorter **Time Period** in the **Custom Date Range** to resolve the issue.
11. When the time series appears there should be numerous peaks showing the trends from to 1984 to the present date that was created for the end date (in this example the end date is 2020-07-05).

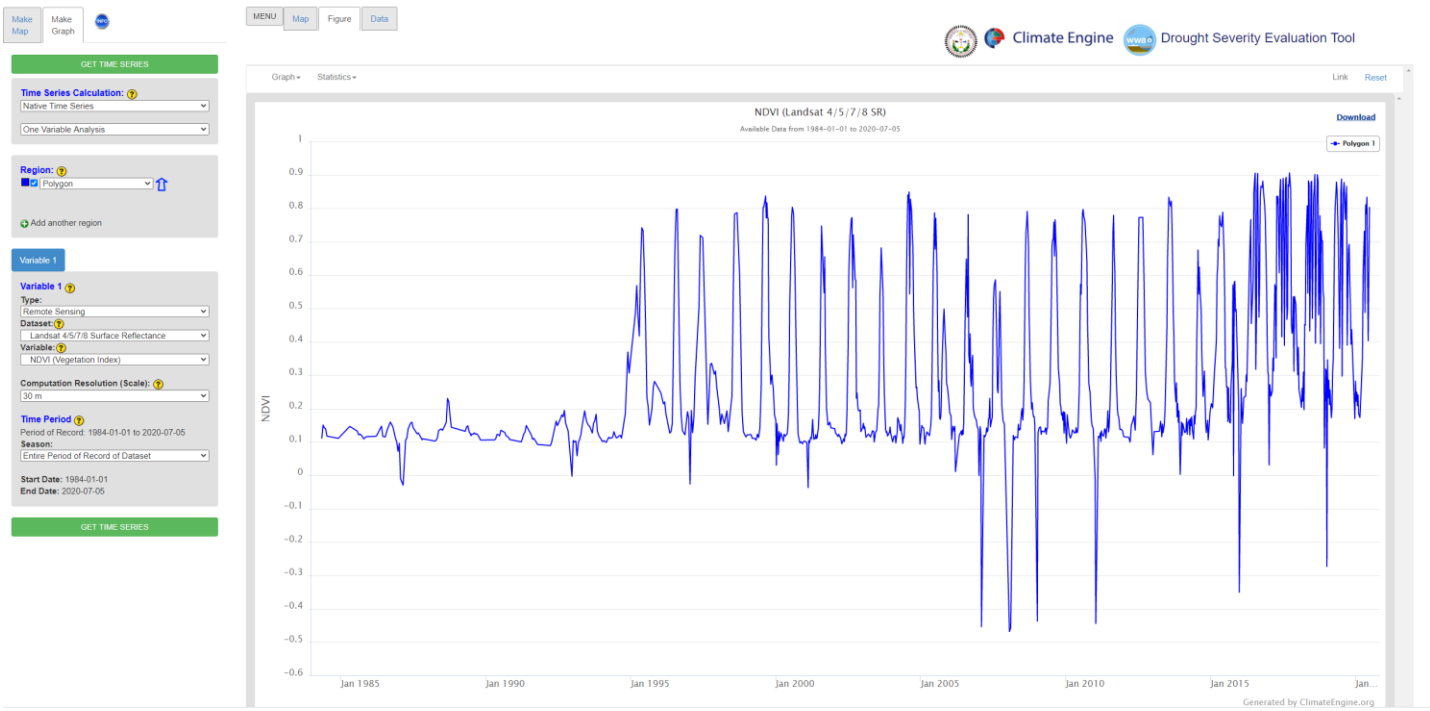


Figure 3. The NDVI data time series for the selected center-pivot irrigation field located near the NAPI Pumpkin Patch. The data time series for the values of NDVI found at this location are from 1984-01-01 to 2020-07-05, the Entire Period of Record of Dataset. The time series shows that irrigation for this field likely started around 1994, with low NDVI values prior to this date and much higher NDVI values after this date. After 1994, this field appears to have multiple cuttings per year, as indicated by the steady increases in NDVI and the sharp declines when cutting occurred.

12. Click on the map around 2013 and drag your mouse to about 2019. As you do this, a blue box will appear over the years selected and indicates where you are zooming into. This will automatically zoom into those years on your time series.

Figure 4. Zooming into a shorter time frame the harvest of a specific year for this center-pivot irrigation field is shown. In this time series example from 2013 to 2019 the NDVI values provide an understanding of the crops and harvests for a particular year. In 2017, there were multiple cuttings which is usually an indication for Alfalfa.

The time series of NDVI values displays patterns in the data that show crop signatures. For example in Figure 9 for 2013 there was a single peak that indicates an annual crop with a greater growth time. An example of an annual crop is corn. In 2015, the center-pivot irrigation field in this exercise had a perennial crop with two harvests. In 2017, there were multiple cuttings for this year which is a typical signature of alfalfa.

13. Click on the small **Reset Zoom** box right under **Polygon 1**on the top right of the figure.
14. In the Make Map panel, under **Time Series Calculation**, select **Summary Time Series**.
15. Under **Year Statistic** for Variable 1, select **Mean**
16. Under the **Time Period** section, leave the first option as Entire Period of Record of Dataset, and for the second drop-down, select **Northern Growing Seasons (Apr – Oct)**.
17. Make sure the **Year Range** is 1984—to the current year the exercise is completed. In this example, the years selected are from 1984—2019. However, if you are running through this exercise in the year 2021 the years for the **Year Range** would be 1984—2020.
18. Click on **Get Time Series** and wait for the time series to load.
    a. Remember if you should get an error DSET can be **Reset** and the analysis can run the process again.

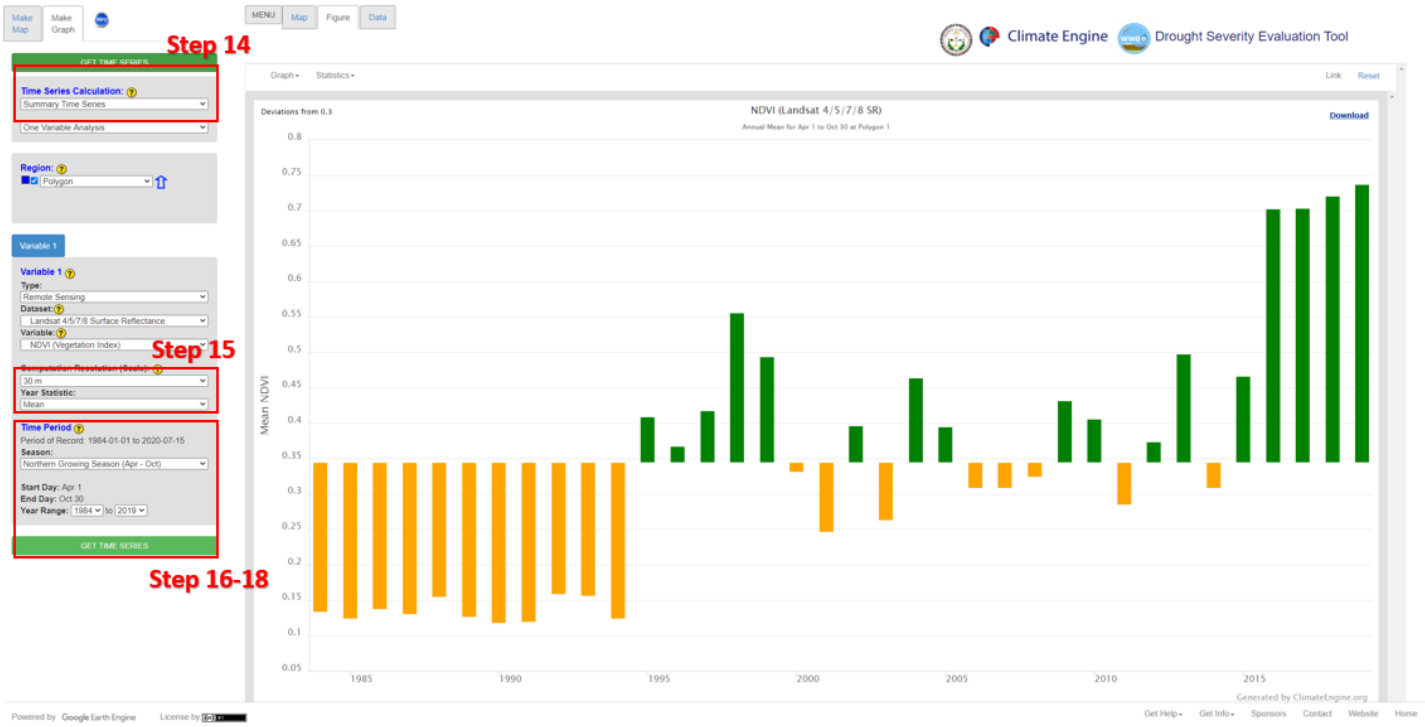


Figure 5. The center-pivot irrigation field located near the NAPI Pumpkin Patch used in this example appears to have not been irrigated until the mid-1990s. This assumption is made based on the low NDVI values from the mid-1980s to about 1995. Guidance on DSET inputs are indicated in this figure for Steps 14 through 18.

Prior to the mid-1990s the center-pivot irrigation field used in this example appears to not have been irrigated. From 1995 to 2019 it appears that irrigation was initiated with the increase of NDVI values for this center-pivot irrigation field. However, with one variable it is difficult to be certain if irrigation was the cause of this increase of NDVI values. Precipitation for this area may have also increased after 1995. Adding a precipitation values as a second variable to this analysis will help determine the impact of irrigation.

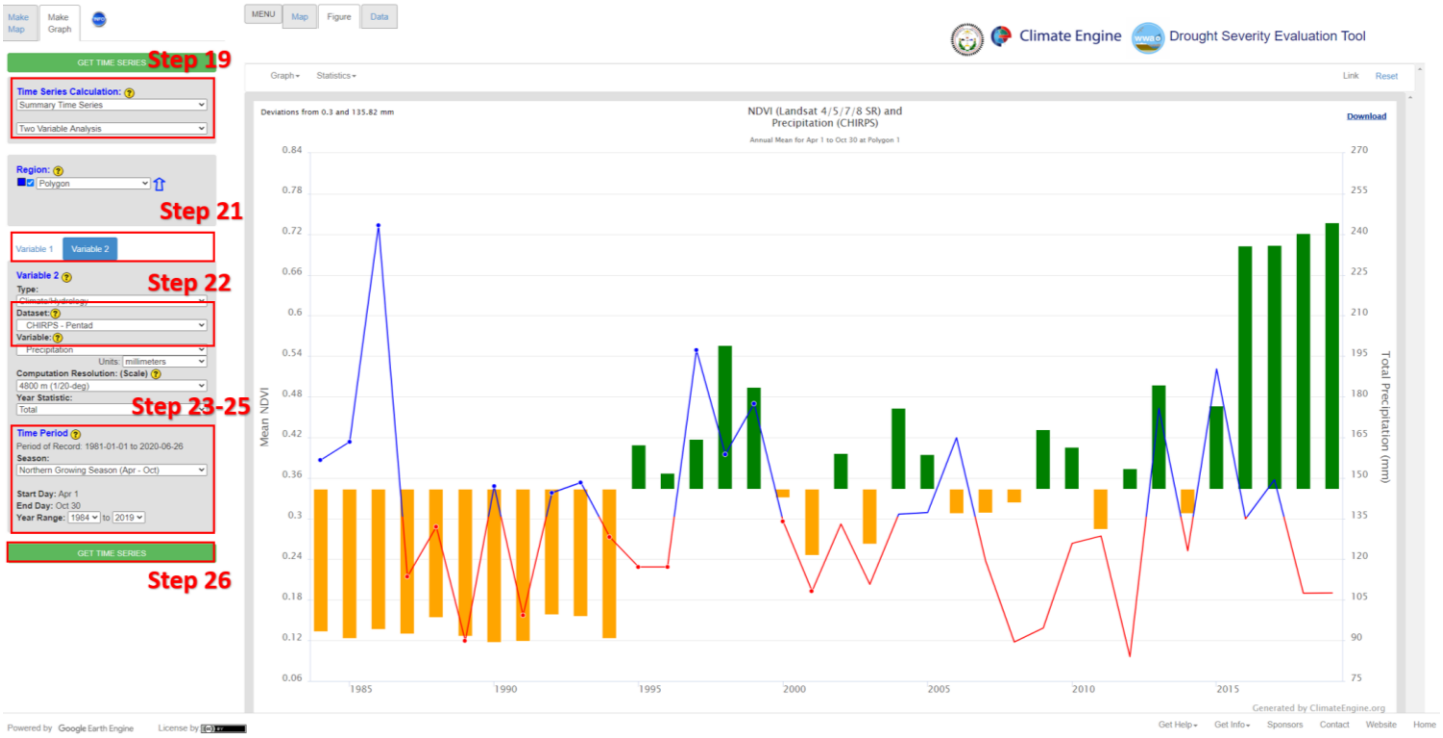


Figure 6. Precipitation and NDVI values are the two variables displayed in this time series. The CHIRPS-Pentad precipitation data is shown as the red and blue line, and the NDVI values are shown as the yellow and green bars. The irrigation of the center-pivot field is shown to have increased the NDVI values based on the precipitation data shown. Steps 19 through 26 are indicated in this figure for location guidance on DSET inputs.

19. Under **Time Series Calculation,** change the second drop-down to **Two Variable Analysis**
20. Don't make any changes to **Variable 1**.
21. Click on **Variable 2,** we are adding precipitation data to understand the influence of irrigation on the center-pivot irrigation field used in this example.
22. Under **Variable 2** for the **Dataset** section, select **CHIRPS – Pentad**, this dataset should be the default.
23. Under **Time Period**, for the first option select Entire Period of Record of Dataset, and for the second drop-down, select the **Northern Growing Seasons (Apr – Oct)** option.
24. Also, under the **Time Period** section change the **Year Range** to 1984 – 2019.
    a. However, keep in mind when making your own analysis like has been done in this exercise you will need to change the years to match your time period of interests. For example, if you are running through this exercise in the year 2021 the years for the **Year Range** would be 1984 – 2020.
25. **Check** to make sure the **Time Period** is the same for **Variable 1** and **Variable 2**.
26. Click on **Get Time Series** and wait for the map to load.

From the mid-1980s to mid-1990s there were peaks of precipitation above average that were not shown to increase NDVI values. The blue section of the precipitation data value line indicates above average whereas the red represents below average. It

would be assumed that an increase of precipitation would also indicate an increase of NDVI values. However, although we observe above average precipitation and increased NDVI values in the late 1990s, NDVI values remain higher than the values prior to 1995, even during periods of below-average precipitation. Therefore, it was be assumed that the consistently higher NDVI values came as a result of irrigation. This is particularly evident from 2007 – 2012, where precipitation was below average and NDVI values remained high.

Additional Resources

- The Applied Remote Sensing Training (ARSET) is a program that is designed to build the capacity of decision-makers to use NASA data. ARSET offers online and in-person trainings for beginners and advanced practitioners alike. Trainings cover a range of datasets, web portals, and analysis tools and their application to air quality, agriculture, disaster, land, and water resources management. http://appliedsciences.nasa.gov/arset

- The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information provides public access to climate and weather data. This particular link provides a deeper look at drought as well as provide projections: https://www.drought.gov/drought/data-maps-tools/tools

- DSET is a spin-off of Climate Engine, a web-based platform for conducting on-the-fly climate analysis: http://climateengine.org/data