



NILE BASIN INITIATIVE
INITIATIVE DU BASSIN DU NIL



Using Sentinel-2 on google earth engine in Crop Type Identification for Irrigation Management in Eastern Nile

By
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Background of the Research



Irrigation operations manager in El Gezira scheme is responsible for the amount of water that every farmer needs to water his farm, but farmers in most times gives fake numbers of their cultivated areas and crop types.

Eastern Nile Technical Regional Office (ENTRO) of Nile Basin Initiative (NBI) is the technical center to support the equitable and adequate use of Nile Water, it has become a concern for it to find a simple tool to assess the use of water in the irrigated scheme to replace the traditional method of field visits. As a team from Sudan, Ethiopia and South Sudan, we provided them with valuable research project and gave them solutions.

In my part of this project I suggested building crop signature library for eastern Nile region and Used Java scripts API in Google earth engine environment to identify phenology parameters and signature for cultivated crops and creating maps for crop types and areas cultivated. In order to monitor small farms and reduce amount of water used in irrigation.



STUDY AREA – Kenana, SUDAN

1. Name: Kenana sugar Scheme

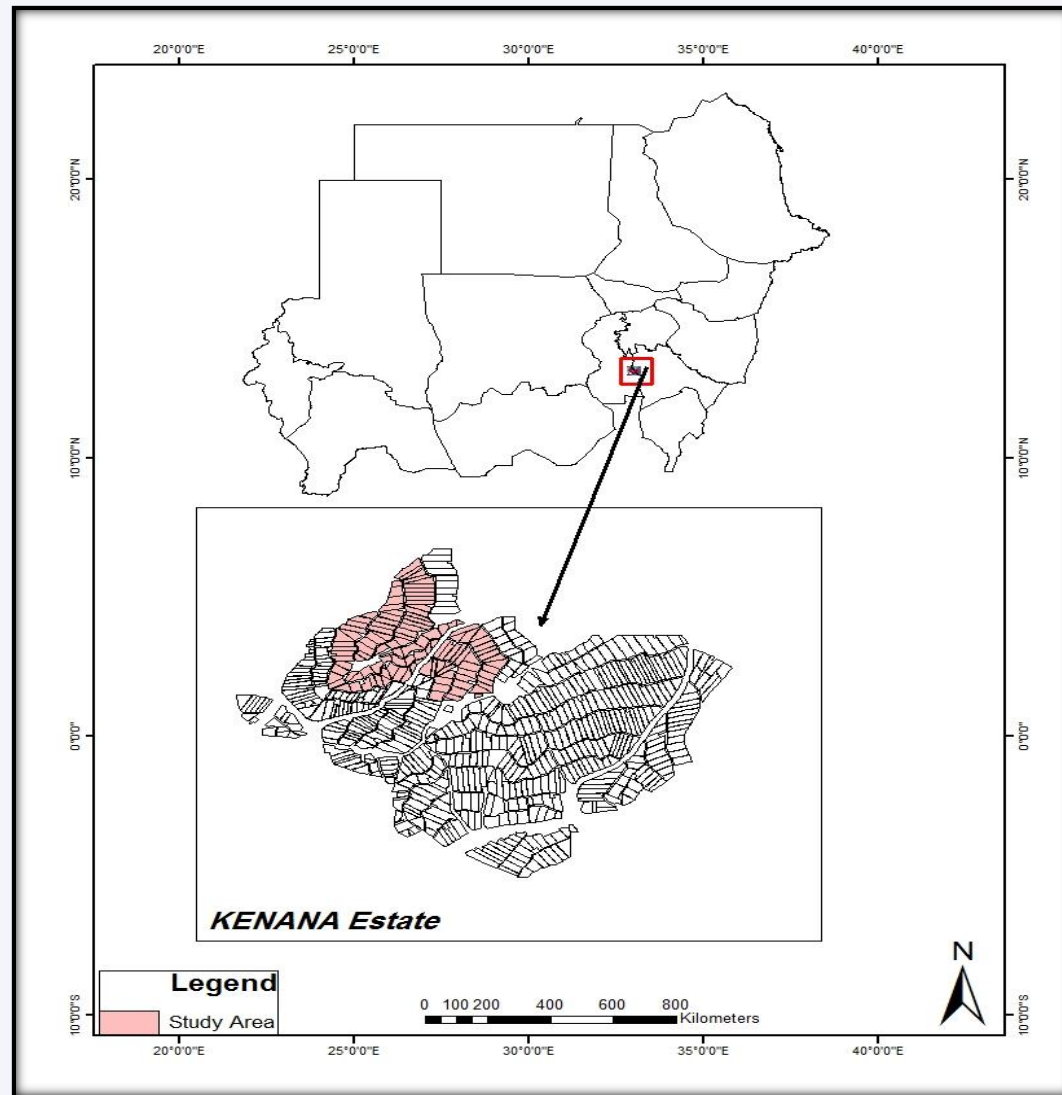
Location: On the eastern bank of the White Nile, approximately 300 Km south of Khartoum, covering an area of 70,000 ha.

Geographic location: it lies with latitudes $13^{\circ} 10' - 13.20^{\circ}$ north and longitude $33^{\circ} 40' - 32.93^{\circ}$ east, at an elevation of 410 m above sea level.

Soil type and topography: The soil of the scheme is fertile and consist mainly of base-saturated heavy textured vertisol of 60 to 70 % clay with a pH greater than 7.5. The area lies on an area of extensive clay plains between the White Nile and the Blue Nile, leading to a predominately flat topography with a gentle slope (0.5 m per Km) towards the White Nile.

Irrigation type: Sugarcane is irrigated by pumping water from the White Nile through six pumping stations that lifts water to 40m above the river level.

Fig : location of Kenana estate in Sudan.



STUDY AREA – Gezira , SUDAN

2. Name: Gezira Scheme.

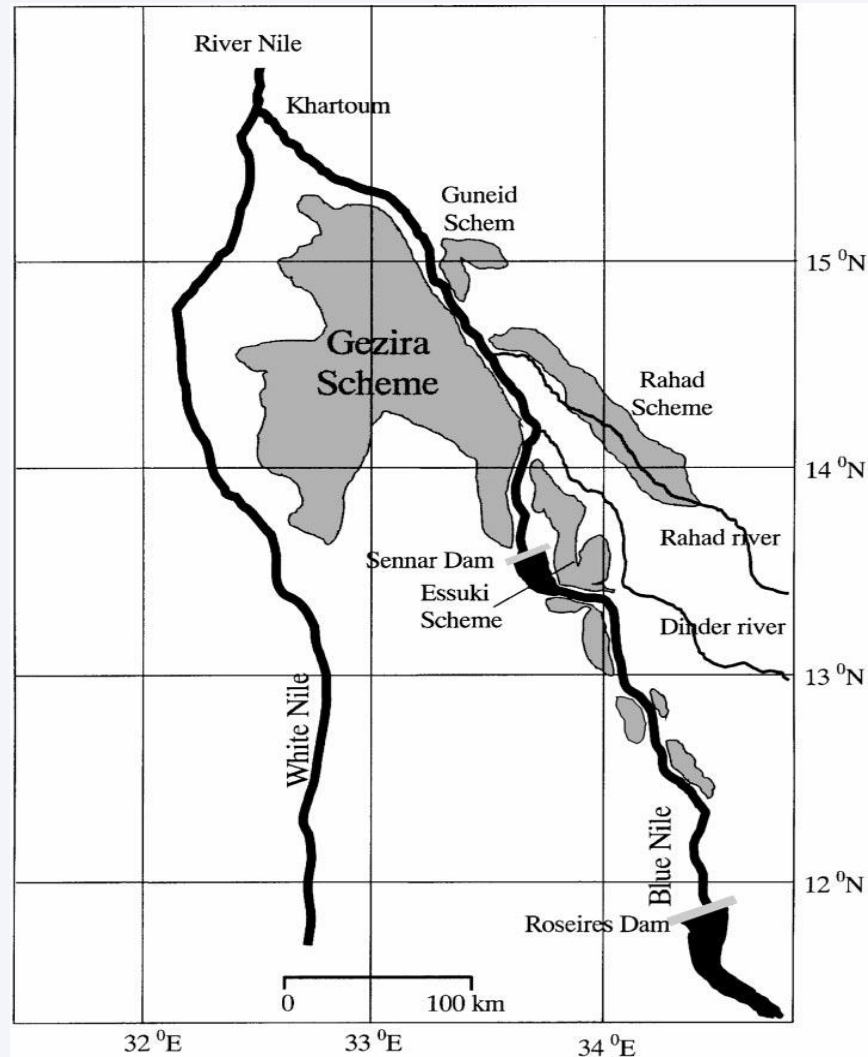
Location: On the western bank of the Blue Nile. The area is gradually increasing by addition of new areas either by desire of people or government policy . 1910 starts with 600 fed. 1970 and later ends with 2.2 M fed.

Geographic location: The scheme is located between latitudes 13300 N and 15150 N, and longitudes 32150 E and 33450 E..

Climate, topography and rainy season: The climate of the region is arid and continental with low average annual precipitation (472 mm at Sennar dam and 160 mm near Khartoum). Altitude ranges from 420 S. to 380 (N. & W. STARTED 1925).The rainy season is 204 A.W. Abdelhadi et al. / Agricultural Water Management 45 (2000) 203±214 short (July-September) with moderate temperature and high humidity. The summer(April-June) is hot and the winter (November-February) is dry and cool. The rest of the period is transitional.

Irrigation type: The agriculture depends on supplementary irrigation from the Blue Nile. Furrow irrigation is the main irrigation system in the scheme.

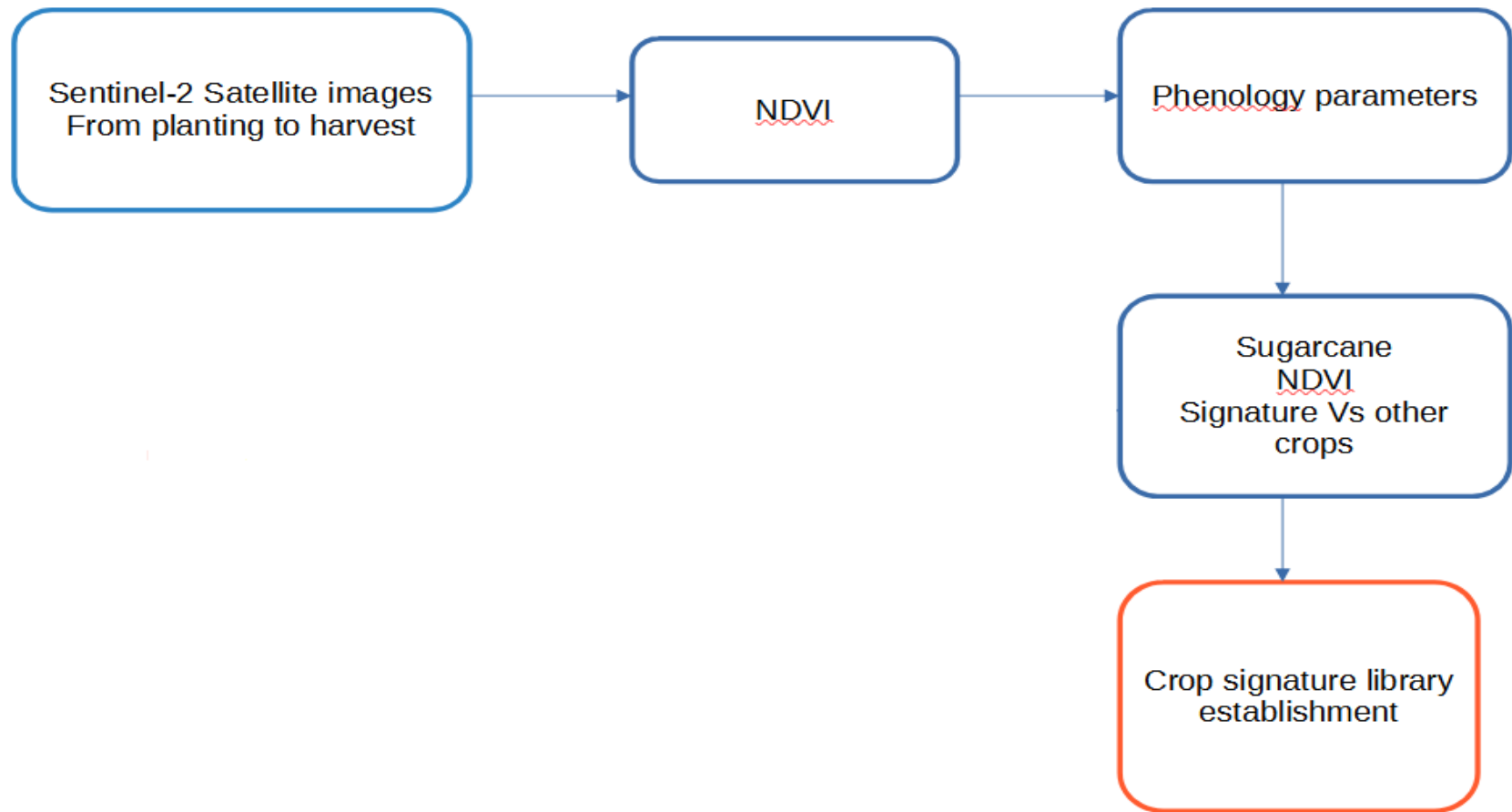
Fig: Major irrigation schemes of the Blue Nile dominated by the Gezira scheme.



Objectives

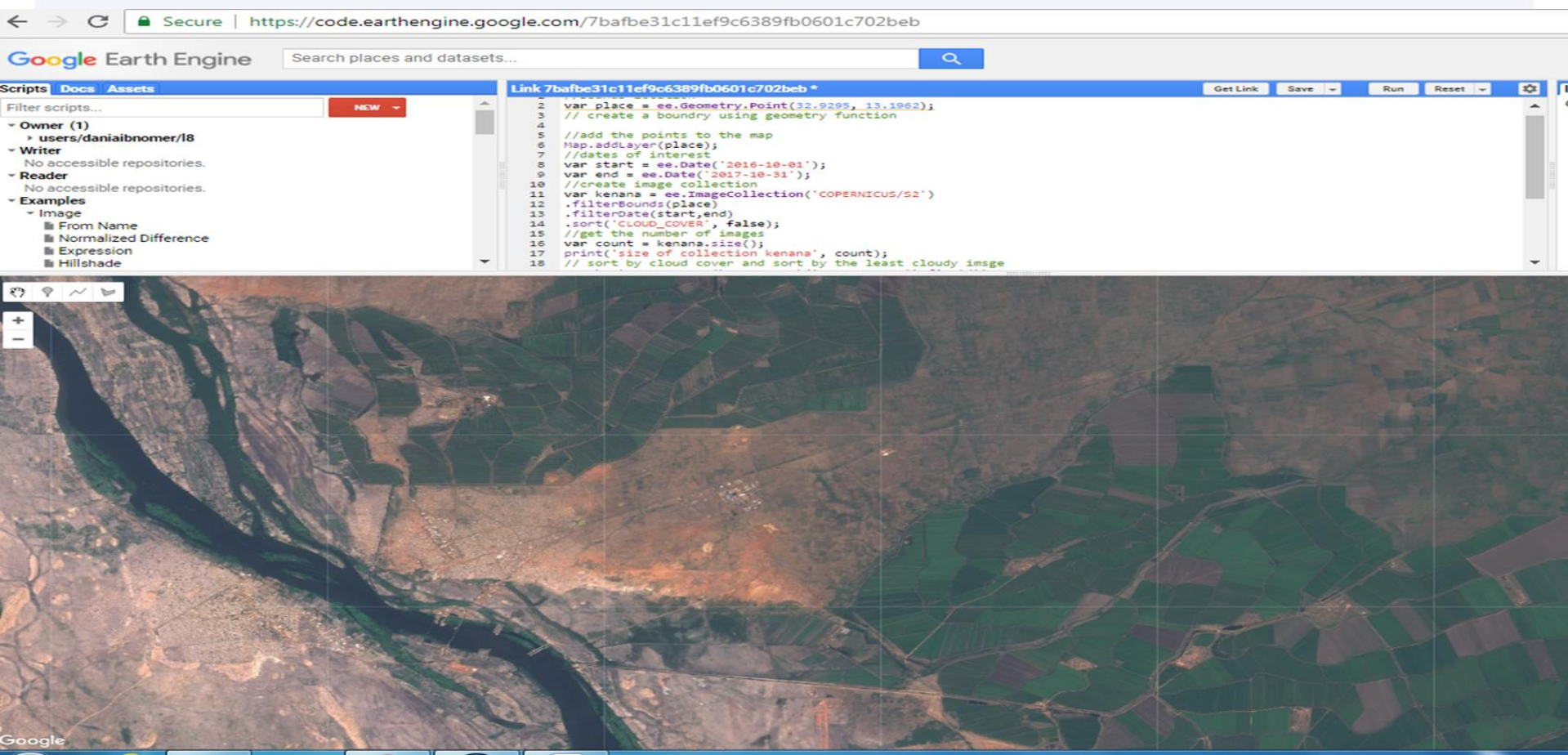
Crop type identification via crop library establishment for eastern Nile area.

Methodology



Methodology Cont.

1. Filter image collection of Sentinel-2A in earth engine with temporal resolution of 10 days from the planting date of crop up to harvest.



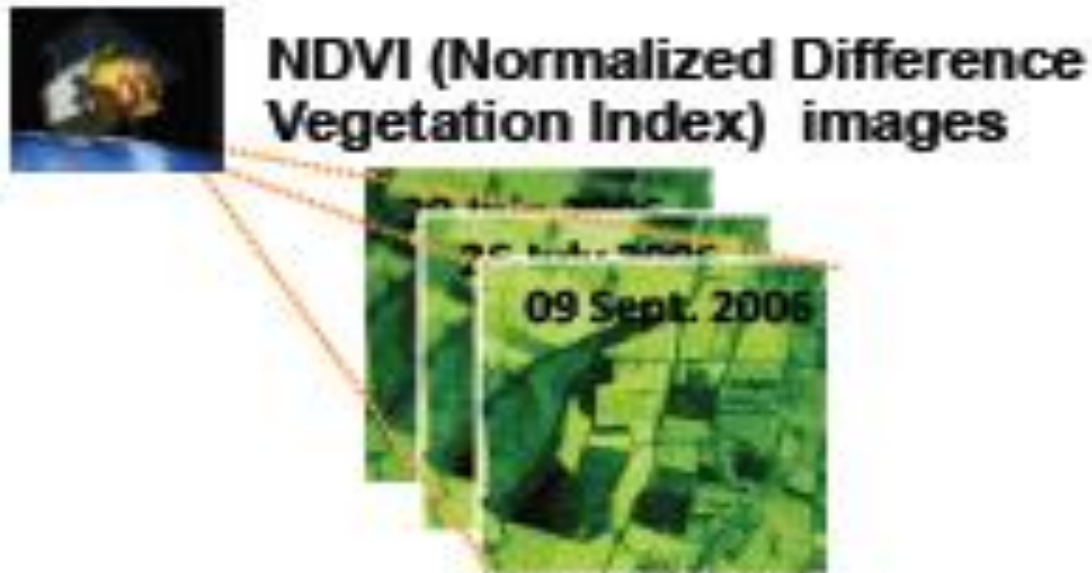
The screenshot displays the Google Earth Engine web interface. The browser address bar shows the URL: <https://code.earthengine.google.com/7bafbe31c11ef9c6389fb0601c702beb>. The interface includes a search bar, a left sidebar with navigation options (Scripts, Docs, Assets), and a main editor area. The script in the editor is as follows:

```
2 var place = ee.Geometry.Point(32.9295, 13.1962);
3 // create a boundry using geometry function
4
5 //add the points to the map
6 Map.addLayer(place);
7 //dates of interest
8 var start = ee.Date('2016-10-01');
9 var end = ee.Date('2017-10-31');
10 //create image collection
11 var kenana = ee.ImageCollection('COPERNICUS/S2')
12 .filters(bounds(place))
13 .filterDate(start,end)
14 .sort('CLOUD_COVER', false);
15 //get the number of images
16 var count = kenana.size();
17 print('size of collection kenana', count);
18 // sort by cloud cover and sort by the least cloudy imgs
```

The bottom half of the image shows a satellite view of a river valley with a grid overlay. The Google logo is visible in the bottom left corner.

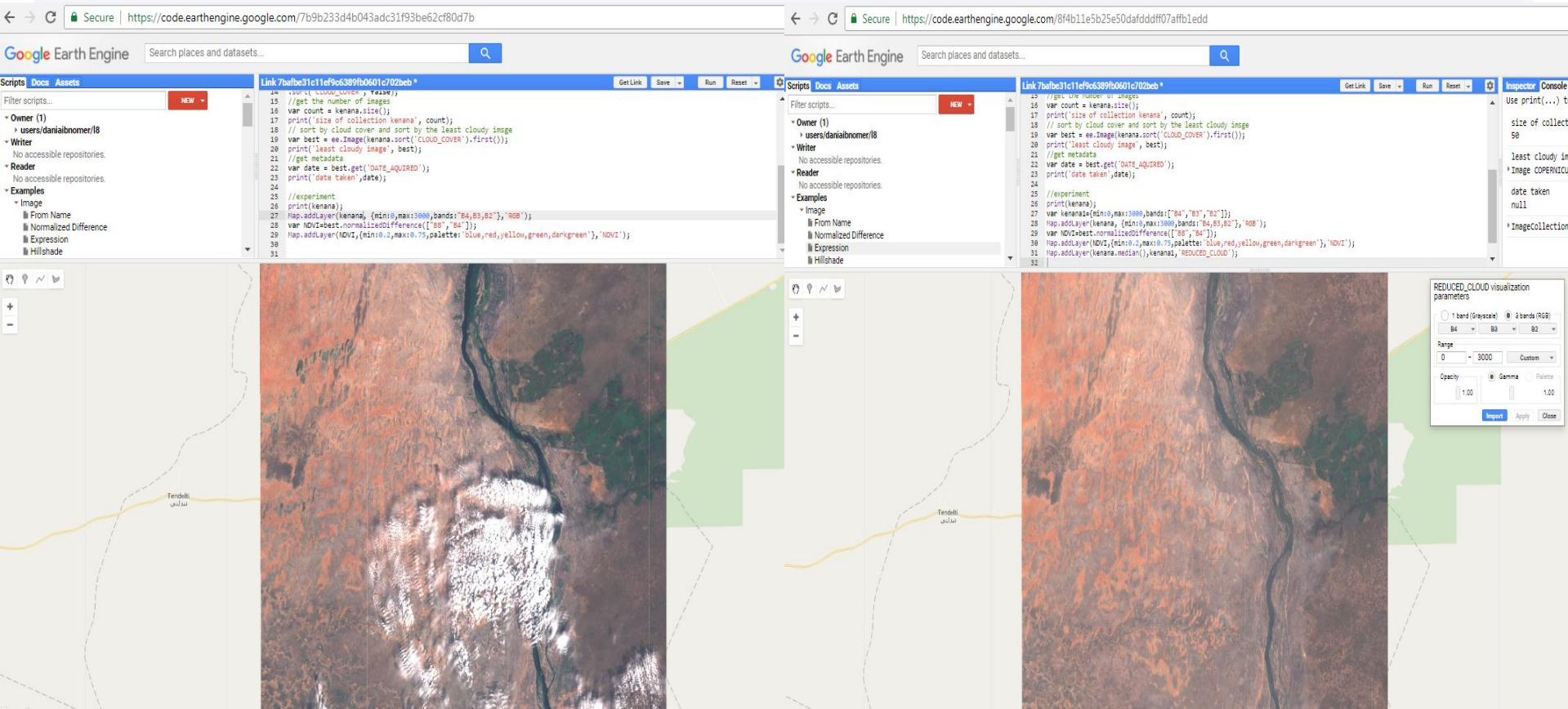
Methodology Cont.

2. Calculate NDVI for images in every single image in earth engine environment.



Methodology Cont.

Atmospheric correction have been done on RGB Sentinel-2A cloudy image then clouds have been reduced using median to eliminate the highest reflectance objects such as clouds.



The screenshot displays the Google Earth Engine interface with a workflow to reduce clouds in a Sentinel-2A image. The workflow is shown in the 'Scripts' panel, and the resulting image is shown in the 'Inspector' panel.

```
15 //get the number of images
16 var count = kenana.size();
17 print('size of collection kenana', count);
18 // sort by cloud cover and sort by the least cloudy image
19 var best = ee.Image(kenana.sort('CLOUD_COVER').first());
20 print('least cloudy image', best);
21 //get metadata
22 var date = best.get('DATE_ACQUIRED');
23 print('date taken', date);
24
25 //experiment
26 print(kenana);
27 Map.addLayer(kenana, {min:0,max:3000,bands:['B4','B3','B2'],'RGB'});
28 var NDVI=best.normalizedDifference(['B8','B4']);
29 Map.addLayer(NDVI,{min:0.2,max:0.75,palette:'blue_red_yellow_green_darkgreen','NDVI'});
30
31
32
```

The Inspector panel shows the 'REDUCED_CLOUD visualization parameters' for the 'kenana' image:

- 1 band (Grayscale) / 3 bands (RGB)
- Bands: B4, B3, B2
- Range: 0 - 3000 (Custom)
- Opacity: 1.00
- Gamma: 1.00
- Palette: null

The map shows the Tensali river area with a 'Tendali' label. The workflow includes steps for getting the number of images, sorting by cloud cover, and applying a median filter to reduce clouds.

Methodology Cont.

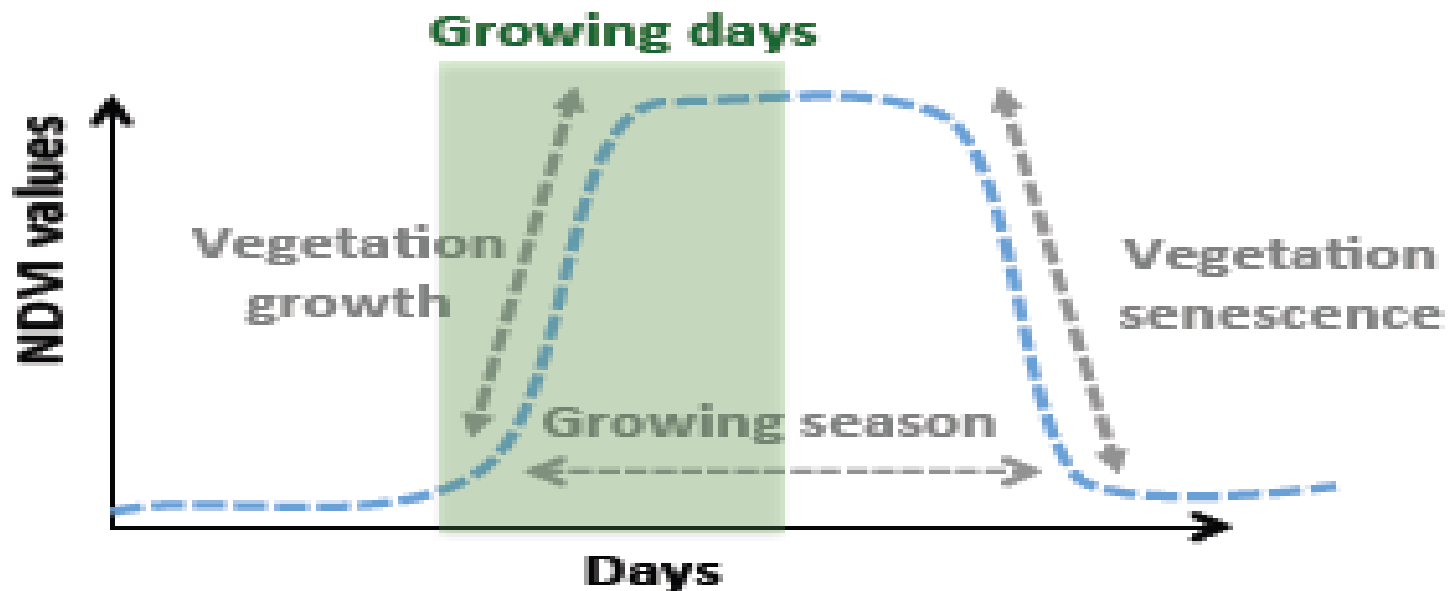
Kenana Area-1 Polygon have been uploaded.

```
New Script * [Get Link] [Save] [Run] [Reset]
Imports (1 entry)
var table: Table_users/daniaibnomer/dndn/area1
  type: FeatureCollection
  id: users/daniaibnomer/dndn/area1
  version: 1529650425936111
  columns: Object (7 properties)
  properties: Object (1 property)
1 print(table);
2
3
4 Map.addLayer(table);
5
```



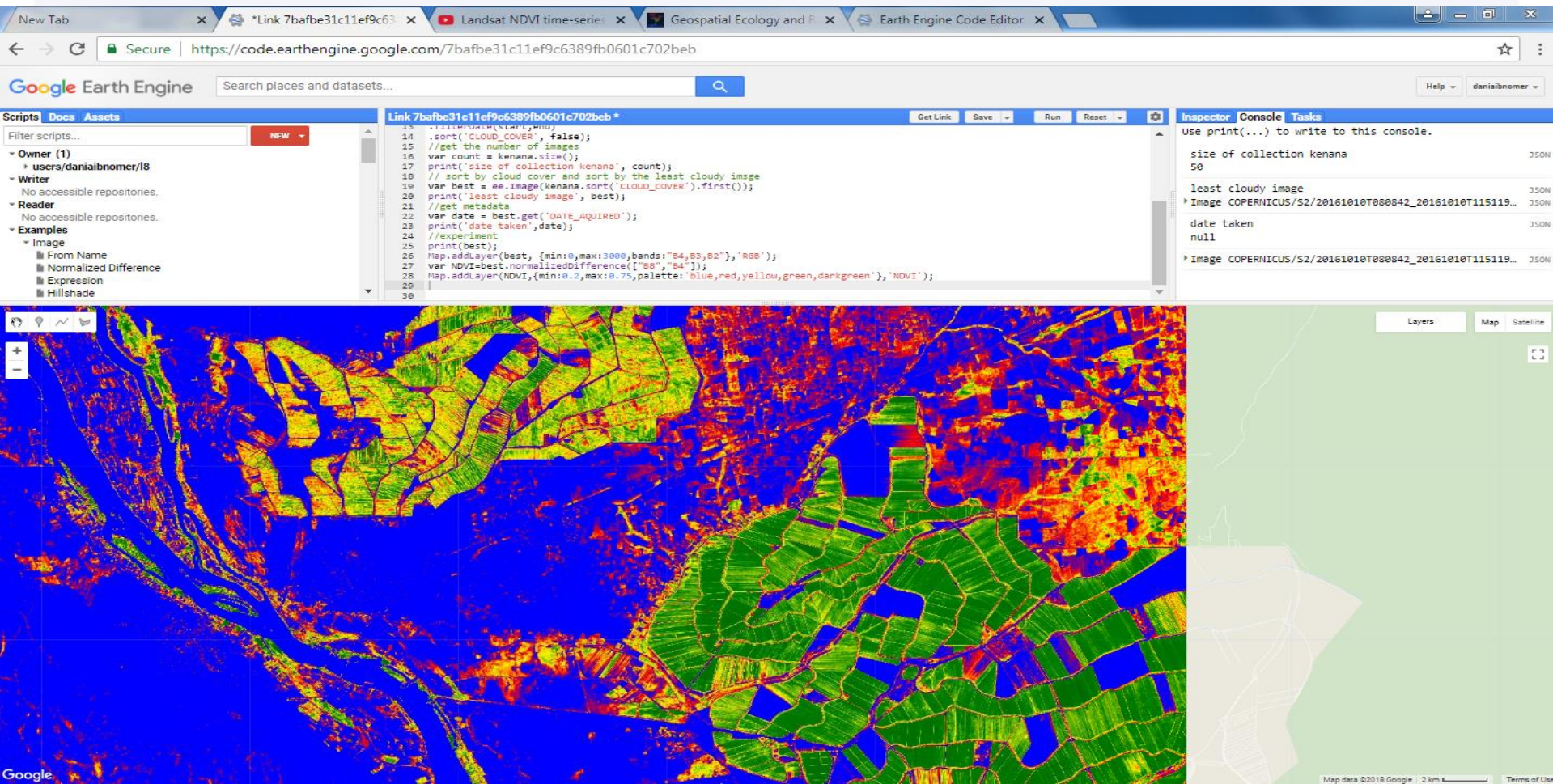
Methodology Cont.

3. Identify Phenology parameters from NDVI times Series in growing days to discriminate crops from each other.



Methodology Cont.

NDVI time series in Kenana Area-1 . First define the year, month of season start time and month of season end. (Press the inspector to get the NDVI time series in any pixel).



The screenshot displays the Google Earth Engine web interface. The browser address bar shows the URL: `https://code.earthengine.google.com/7bafbe31c11ef9c6389fb0601c702beb`. The interface includes a search bar, a sidebar with user information (Owner: users/daniaibnomer/18, Writer, Reader, Examples), and a main workspace. The workspace contains a script titled "Link 7bafbe31c11ef9c6389fb0601c702beb" with the following code:

```
14 .filterDate(start, end);
15 .sort('CLOUD_COVER', false);
16 var count = kenana.size();
17 print('size of collection kenana', count);
18 // sort by cloud cover and sort by the least cloudy image
19 var best = ee.Image(kenana.sort('CLOUD_COVER').first());
20 print('least cloudy image', best);
21 //get metadata
22 var date = best.get('DATE_ACQUIRED');
23 print('date taken', date);
24 //experiment
25 print(best);
26 Map.addLayer(best, {min:0,max:3000,bands:['B4','B3','B2'],'RGB'});
27 var NDVI=best.normalizedDifference(['B5','B4']);
28 Map.addLayer(NDVI,{min:0.2,max:0.75,palette: 'blue,red,yellow,green,darkgreen'}, 'NDVI');
```

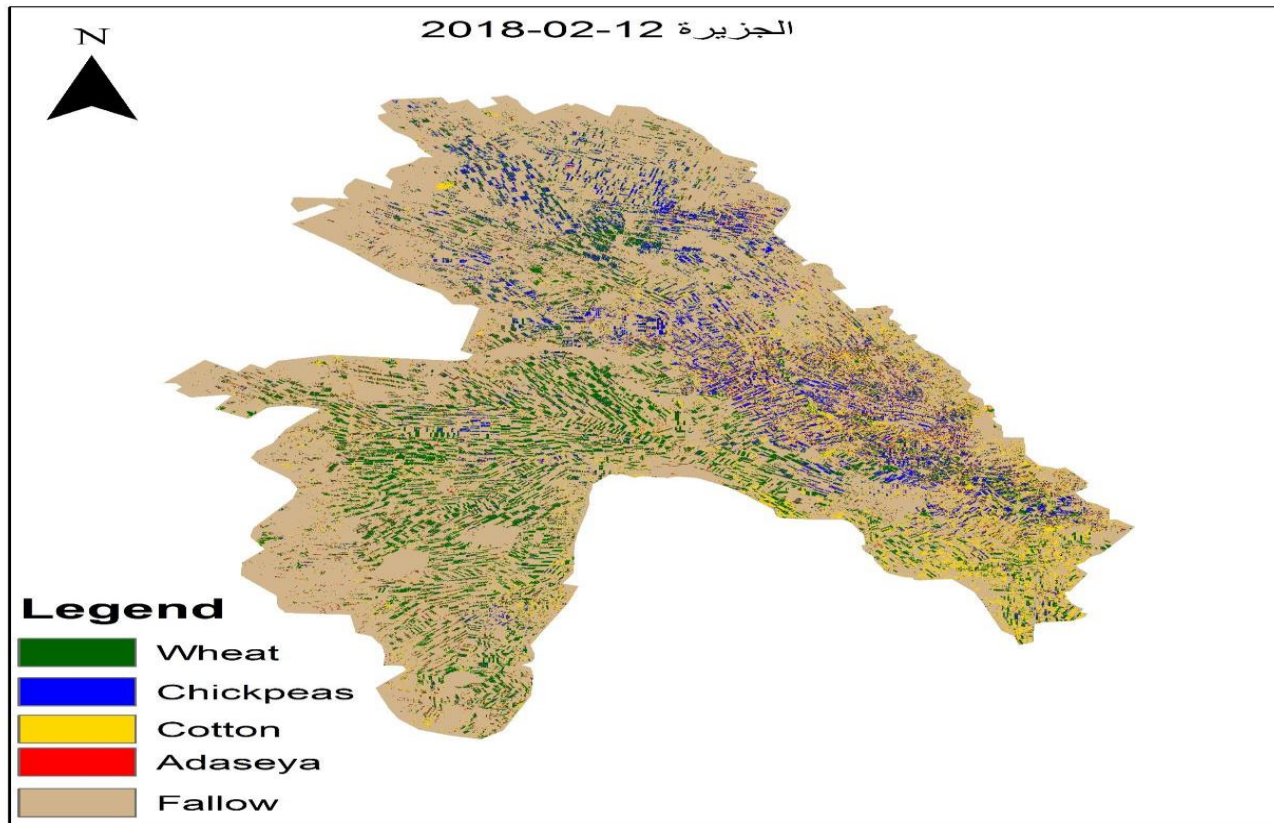
The right-hand side of the interface shows the "Inspector" and "Console" tabs. The console displays the following output:

```
Use print(...) to write to this console.
size of collection kenana 350N
50
least cloudy image 350N
Image COPERNICUS/S2/20161010T080842_20161010T115119... 350N
date taken 350N
null
Image COPERNICUS/S2/20161010T080842_20161010T115119... 350N
```

The main map area shows a satellite view of a landscape with a color-coded NDVI overlay. The overlay uses a palette where blue represents low NDVI values (likely water or bare soil), green represents moderate values (vegetation), and yellow/red represents high values (dense vegetation). The map includes standard navigation controls (pan, zoom, layers, map, satellite) and a scale bar at the bottom right.

Methodology Cont.

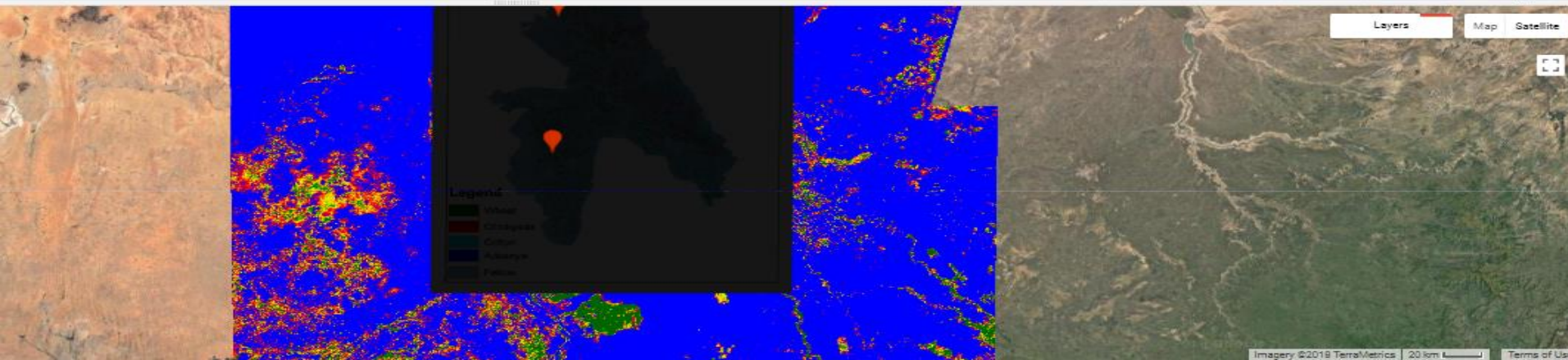
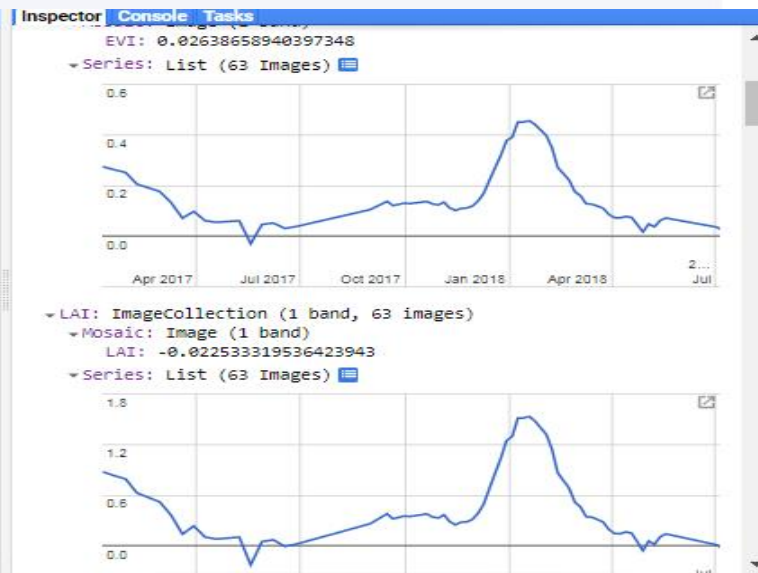
Import Gezira scheme crops map and move NDVI time series to Gezira scheme, to identify different crops such as wheat and cotton and compare their NDVI signature.



Methodology Cont.

Display vegetation indices such as LAI, EVI and NDVI to identify subtle differences.

```
nk 4cbe52038dda03a15446979c6def63a3 *
112 - '(((3.618 * (2.5 * ((nir - red) / (nir + 6 * red - 7.5 * bl + 1)))) - 0.118)', {
113   'nir': image.select('B8'),
114   'red': image.select('B4'),
115   'bl': image.select('B2')});
116   return image.addBands(lai.rename('LAI'));
117 var LAI = filtered.map(addLAI).select(13);
118 Map.addLayer(LAI, {min:0.2, max: 0.7, palette:'blue,red,yellow,green,darkgreen'}, 'LAI');
119
120 Map.addLayer(crop, {min:0,max:3000,bands:"b3,b2,b1"});
121
122 // Use these bands for prediction.
123 var bands = ['B2', 'B3', 'B4', 'B5', 'B6', 'B7','B8','B9', 'B10', 'B11'];
124
125
126 var series = ui.Chart.image.doySeriesByRegion(
127   NDVI, 0, CROP_POINTS, ee.Reducer.mean(), 10, ee.Reducer.mean(), 'label');
128 var series = ui.Chart.image.seriesByRegion(NDVI,CROP_POINTS, ee.Reducer.mean(),0,100, 'system:time_start','lab
129
130 print(series);
131
132 // Overlay the points on the imagery to get training.
133 var training = best.sampleRegions({
134   collection: CROP_POINTS,
135   properties: ['label'],
136   scale: 30
137 });
138
139 // Train a CART classifier with default parameters.
140 var trained = ee.Classifier.cart().train(training, 'label',bands);
141
142
143 // Classify the image with the same bands used for training.
144 var classified = best.classify(trained);
145
146 // Display the inputs and the results.
147
```



Methodology Cont.

4. Using crop calendar and NDVI time series to Identify different crops.

Gezira Scheme –Crop Calendar

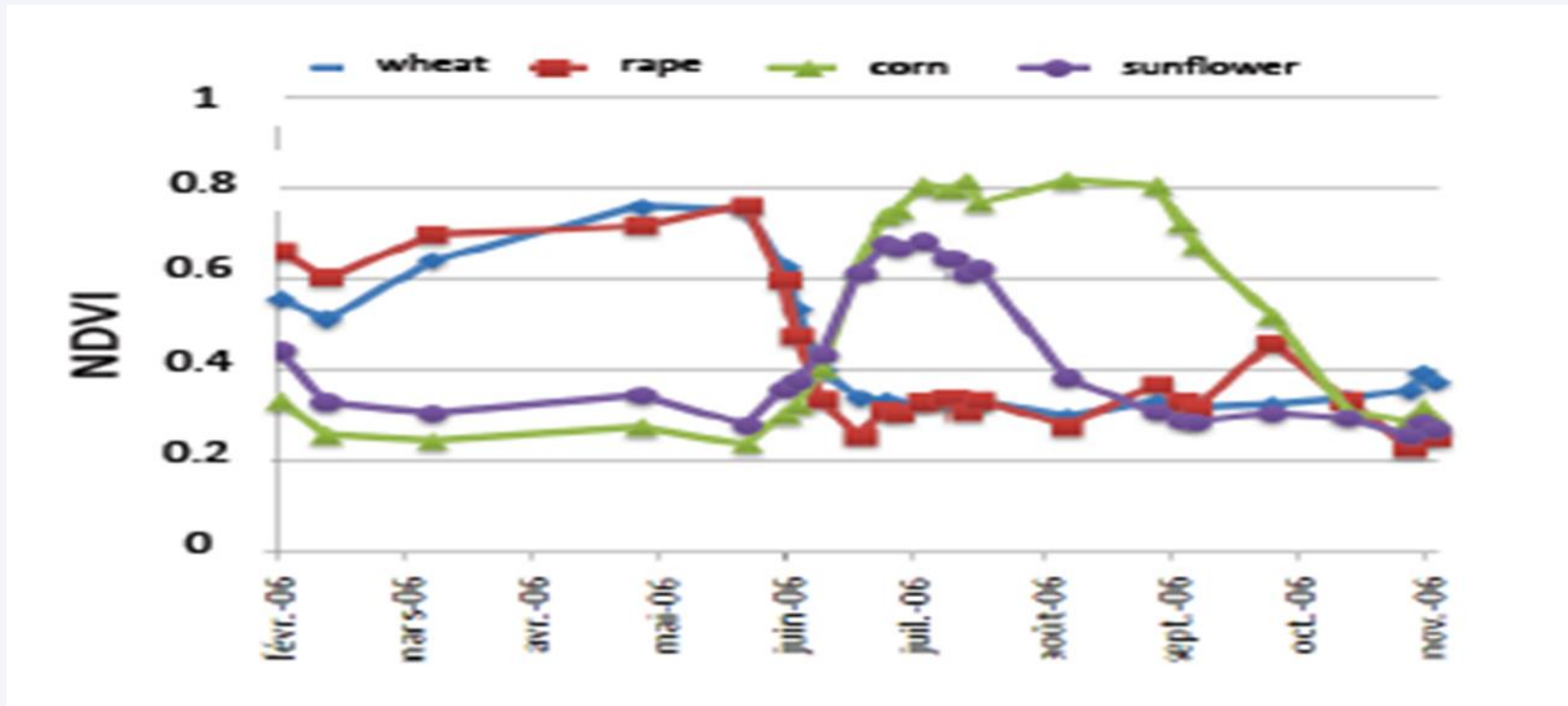
COMPLICATION

May		June			July			Aug			Sep			Oct			Nov.			Dec.			Jan.			Feb			March			Apr									
1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd	nil											
	Fur + Filling	Ground Nut																												Summer Water											
					Sorghum																																				
							Acala cotton																																		
								Els cotton																																	
										Vegetables																															
																Wheat																									

SUGAR CANE ONE CROP

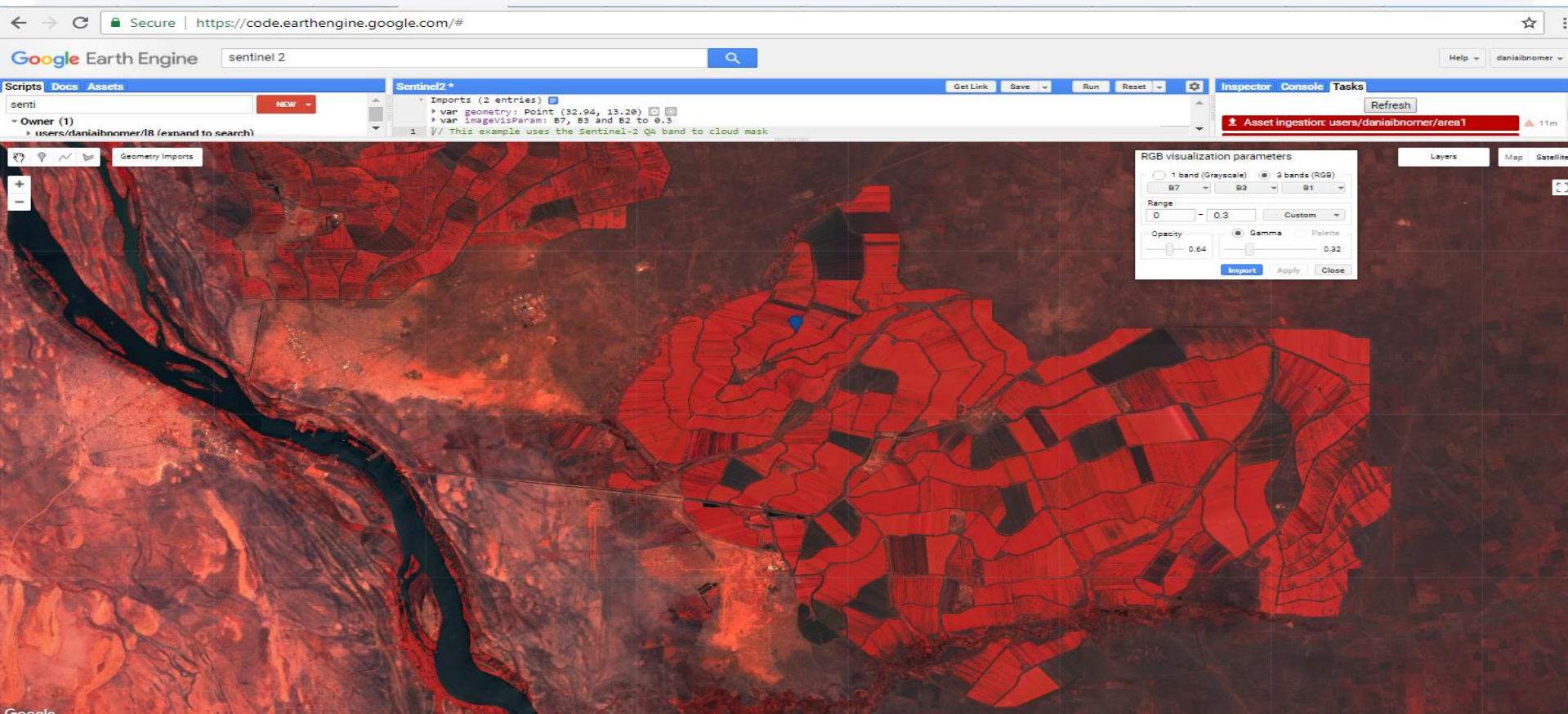
CLEAR EXAMPLE FOR DIFFERENCES

Methodology



Results

1. Vegetation band combination (7,3,1) have been shown on sentinel 2A images using Earth Engine to highlight vegetated areas.



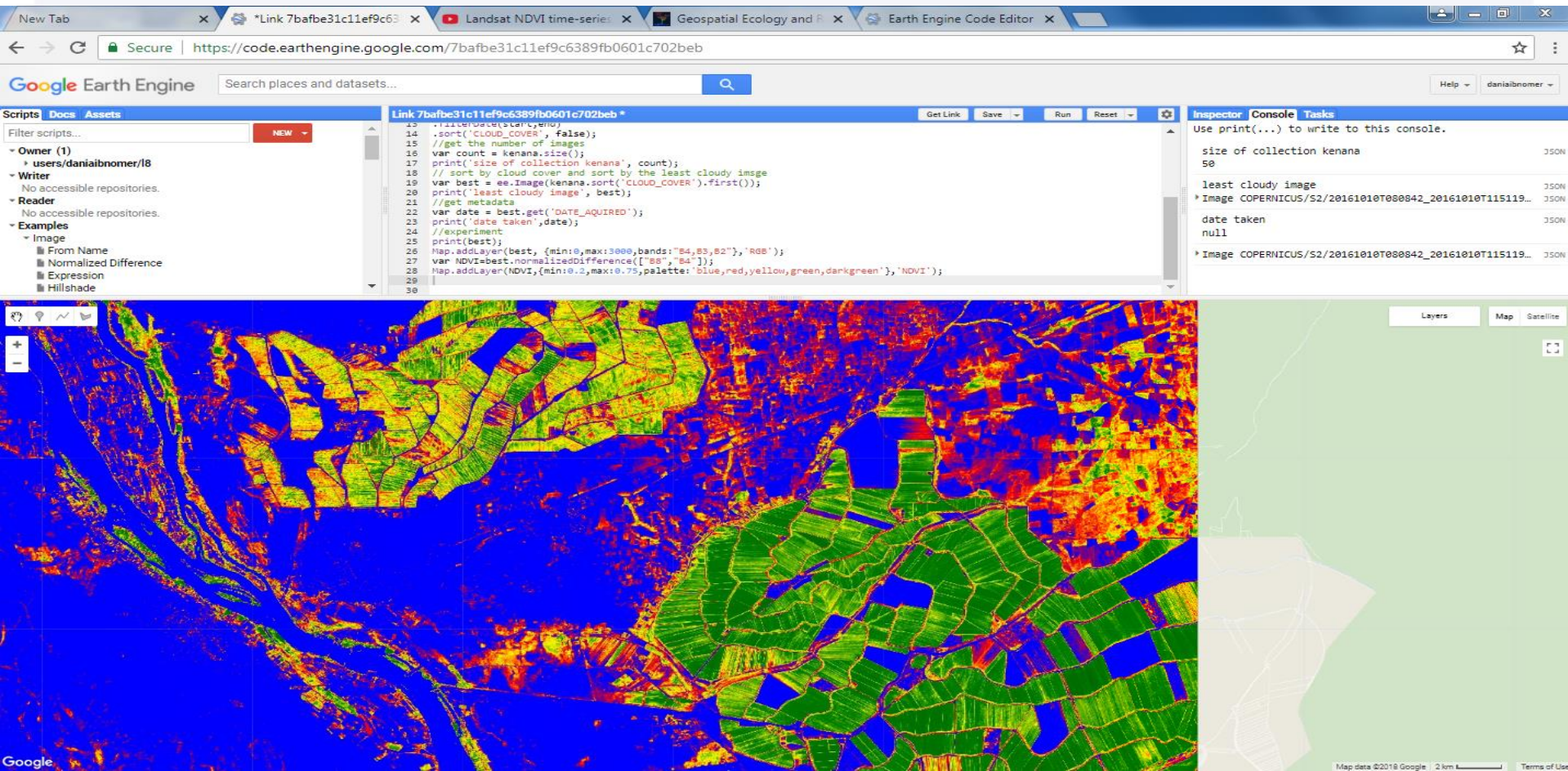
The screenshot displays the Google Earth Engine web interface. The browser address bar shows the URL <https://code.earthengine.google.com/#>. The search bar contains the text "sentinel 2". The main interface is divided into several sections:

- Scripts Panel:** Shows a script named "sentinel 2" with the following code:

```
var geometry = Point(32.94, 13.20);  
var imageVisParam = {  
  bands: ['B7', 'B3', 'B1'],  
  min: 0,  
  max: 0.3,  
  gamma: 1.0,  
  palette: 'Reds'  
};  
// This example uses the Sentinel-2 QA band to cloud mask
```
- Inspector Panel:** Shows the visualization parameters for the selected layer, including:
 - Band selection: 3 bands (RGB)
 - Range: 0 to 0.3
 - Opacity: 0.64
 - Gamma: 0.32
- Map:** Displays a satellite image of a river delta region with a red overlay highlighting vegetated areas. A blue location pin is visible on the map.

Results Cont.

2. NDVI equation have been applied to identify vegetation health, planting stage and crop signature.



The screenshot displays the Google Earth Engine web interface. At the top, the browser address bar shows the URL: `https://code.earthengine.google.com/7bafbe31c11ef9c6389fb0601c702beb`. The interface includes a search bar, a 'Scripts' panel on the left, a central code editor, and an 'Inspector/Console' panel on the right.

The code editor contains the following JavaScript code:

```
13 //filterDate(startDate,endDate)
14 .sort('CLOUD_COVER', false);
15 //get the number of images
16 var count = kenana.size();
17 print('size of collection kenana', count);
18 // sort by cloud cover and sort by the least cloudy image
19 var best = ee.Image(kenana.sort('CLOUD_COVER').first());
20 print('least cloudy image', best);
21 //get metadata
22 var date = best.get('DATE_ACQUIRED');
23 print('date taken', date);
24 //experiment
25 print(best);
26 Map.addLayer(best, {min:0,max:3000,bands:['B4','B3','B2'],'RGB'});
27 var NDVI=best.normalizedDifference(['B5','B4']);
28 Map.addLayer(NDVI,{min:0.2,max:0.75,palette:'blue,red,yellow,green,darkgreen'},'NDVI');
29
30
```

The console on the right shows the output of the script:

```
Use print(...) to write to this console.
size of collection kenana 350N
50
least cloudy image 350N
Image COPERNICUS/S2/20161010T080842_20161010T115119... 350N
date taken 350N
null
Image COPERNICUS/S2/20161010T080842_20161010T115119... 350N
```

The main map area displays a satellite image of a landscape with a color-coded NDVI overlay. The overlay uses a palette where blue represents low vegetation (NDVI < 0.2), red and yellow represent intermediate vegetation, and green and dark green represent high vegetation (NDVI > 0.75). The map shows a complex pattern of agricultural fields and natural vegetation. The bottom right corner of the map includes a 'Layers' panel, a 'Map' button, and a 'Satellite' button. The Google logo is visible in the bottom left corner.

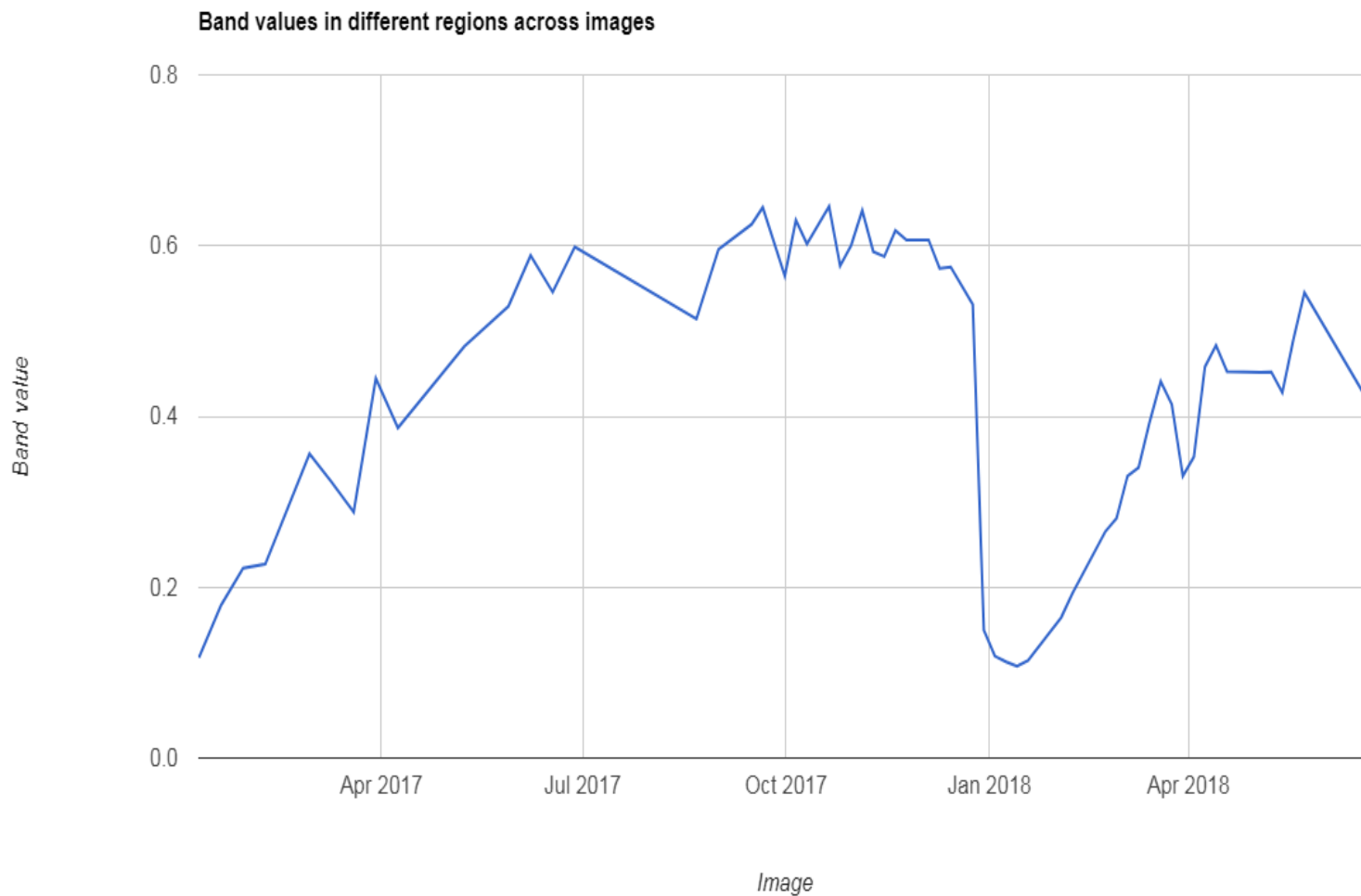
Results Cont.

3. NDVI time series for predefined points of cotton, wheat, abu70, sugarcane and fallow area have been displayed.

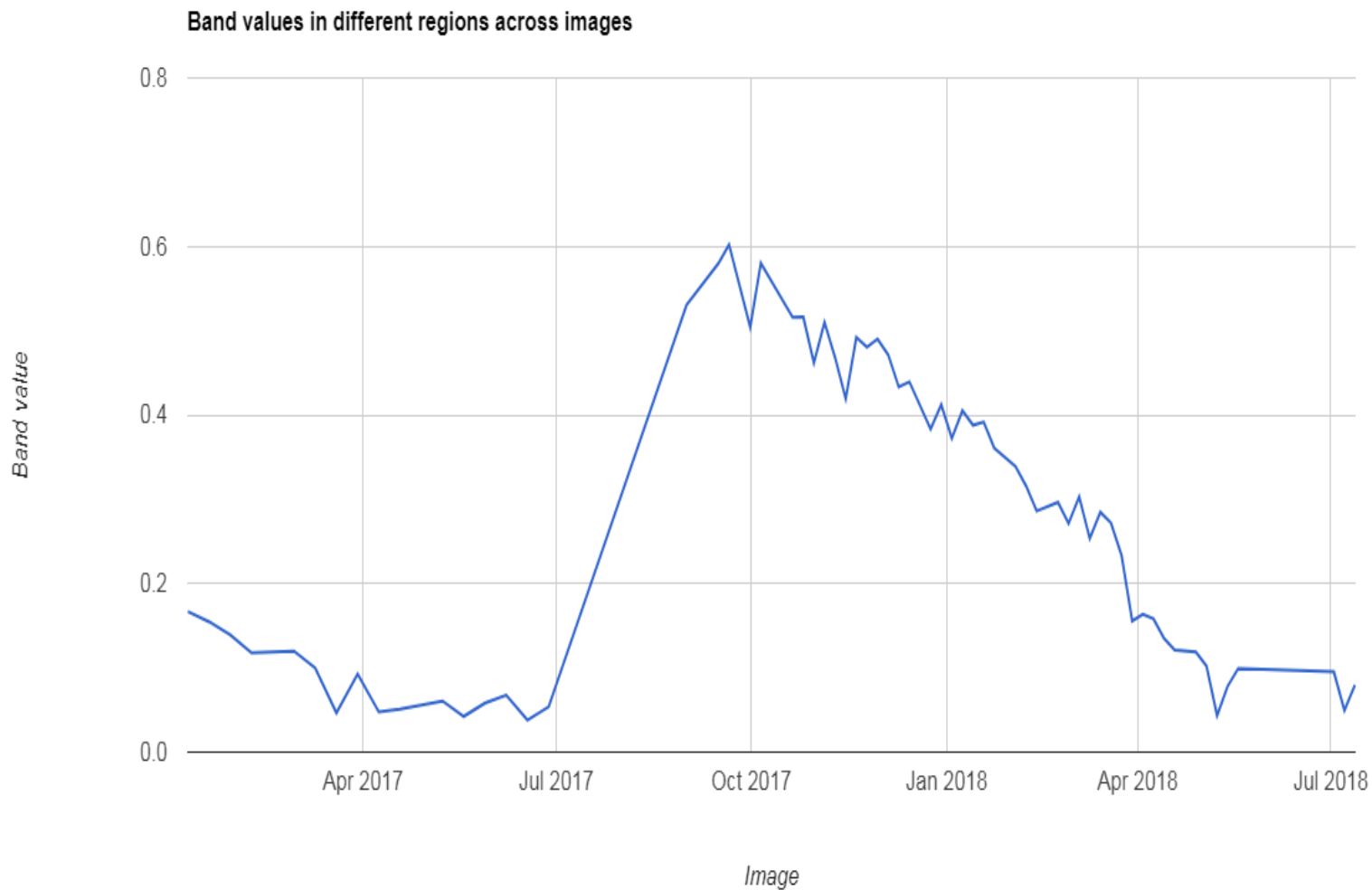
Results Cont.

4. Create separate NDVI signature profile for cotton, wheat, abu70, sugarcane and fallow area .

Sugarcane NDVI signature

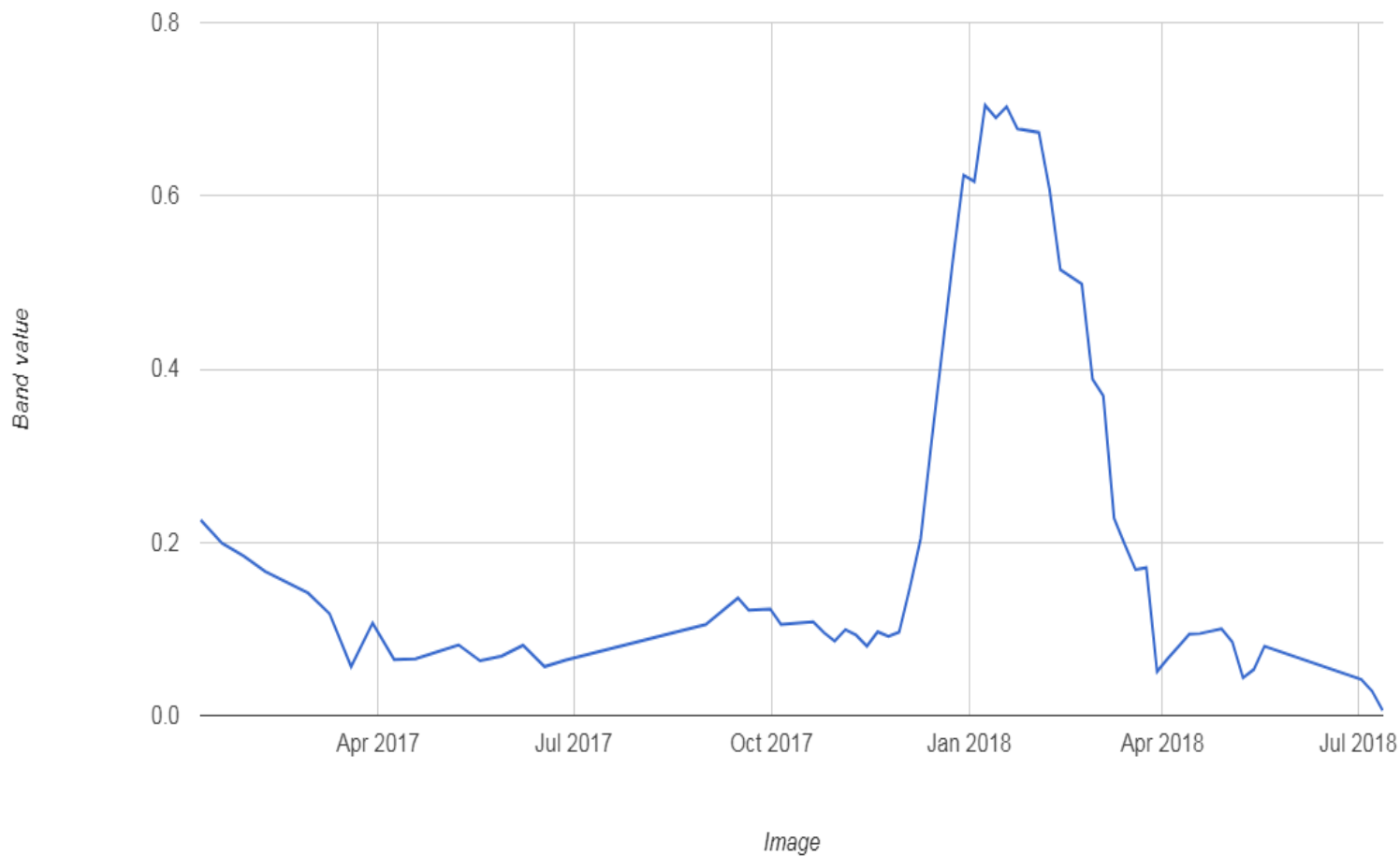


Cotton NDVI signature

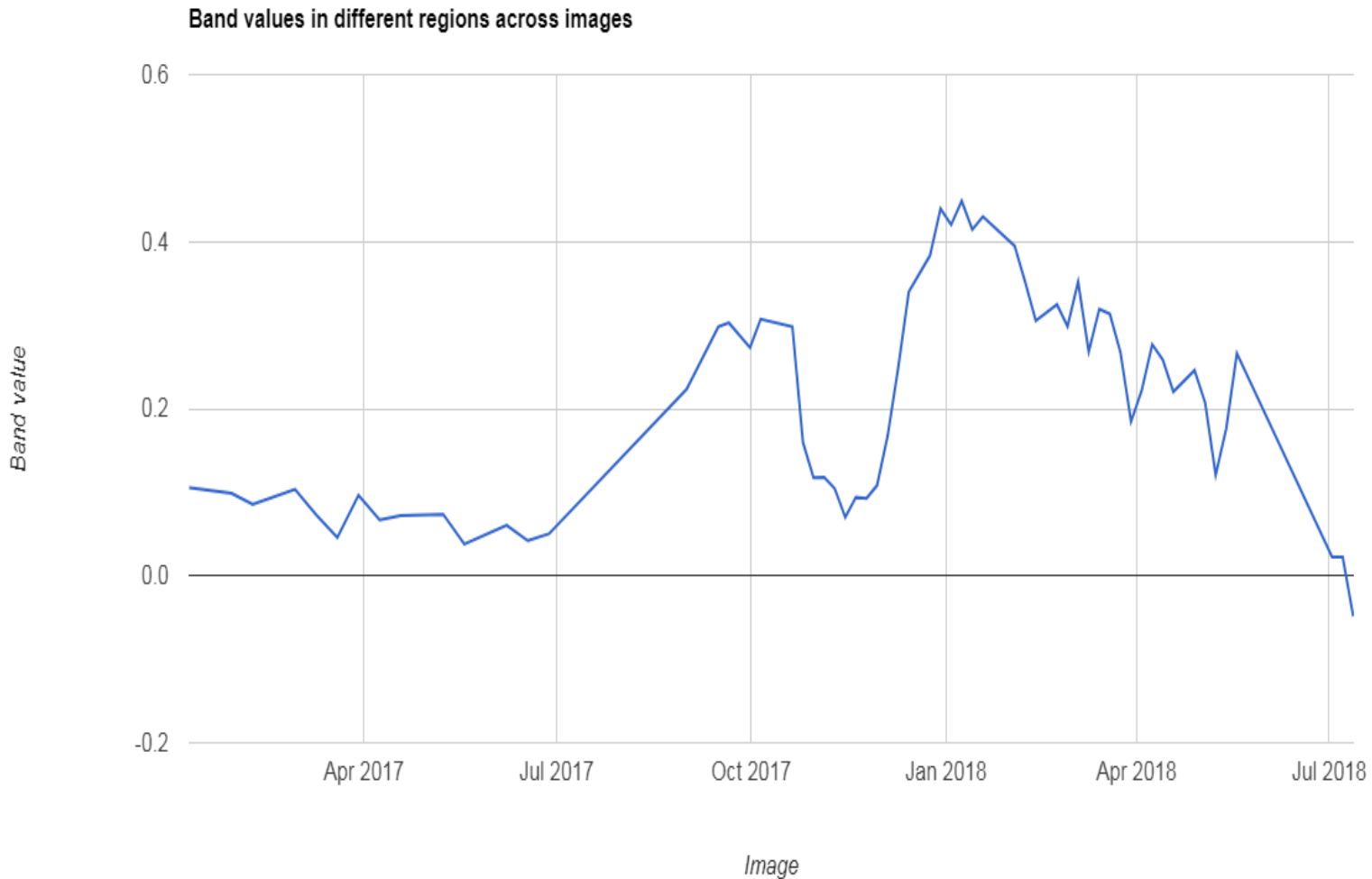


Wheat NDVI signature

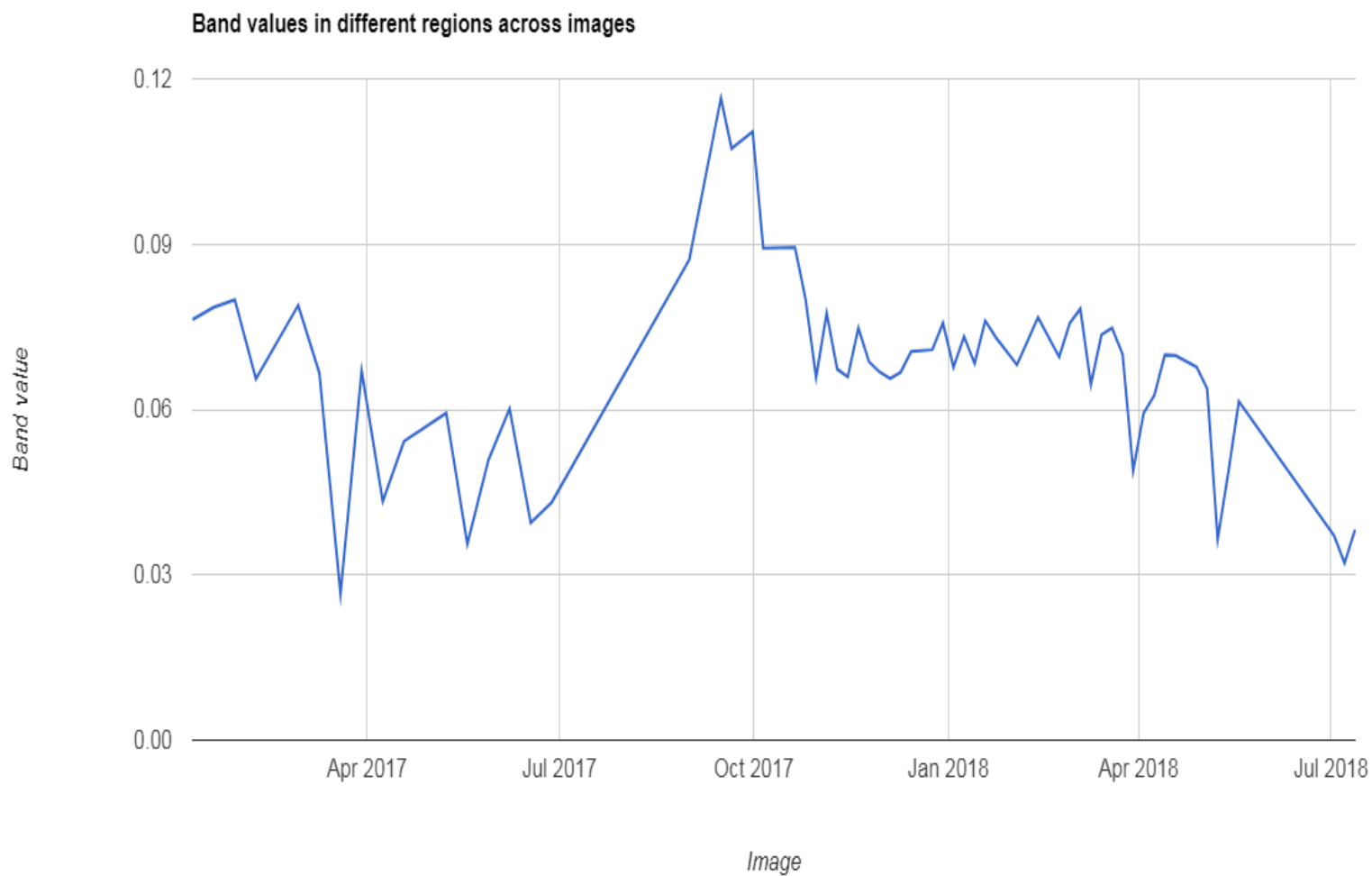
Band values in different regions across images



Abu 70 NDVI signature



Fallow Area NDVI signature



Conclusion

Highest NDVI values of 0.7 have been obtained in wheat and sugarcane areas near harvest stage and the lowest values have been obtained on fallow areas which is a good indicator of crop stage and calendar.

The fluctuation in the NDVI time series chart is due to soil, clouds and other atmospheric effects which have been calibrated using different vegetation indices such as LAI, EVI.

NDVI time series charts have shown high correlation with the plant calendar, growth stage and health.

Crop NDVI signature libraries have been established for the Eastern Nile area.

Recommendations

Advanced studies must be made specially in using different vegetation indices to eliminate soil, temperature, cloud and other atmospheric effects which affect the accuracy of crop identification and area calculations.

Continue building the crop library which we have established to make crop monitoring in Eastern Nile area easier and more precise.



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**THANK
YOU!**

