Anand Agricultural University, Anand

DROUGHT MONITORING IN AGRICULTURE USING RS AND GIS

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Introduction

❑ What is drought ?

Drought is a prolonged period of abnormally low precipitation resulting in a shortage of water supply, whether it be for agricultural, industrial, or domestic use.

❑ Types of drought :

a) Meteorological Drought
b) Hydrological Drought
c) Agricultural Drought
d) Socioeconomical Drought

❑ What is Agriculture Drought ?

Agricultural drought is a type of drought that occurs when there is a shortage of moisture in the soil that negatively impacts the growth and yield of crops, leading to economic losses for farmers and food shortages for communities.

Objective

- To create a basic drought monitoring map for a small agricultural area using RS data.
- Analyze the relationship between drought conditions and crop productivity.

Material

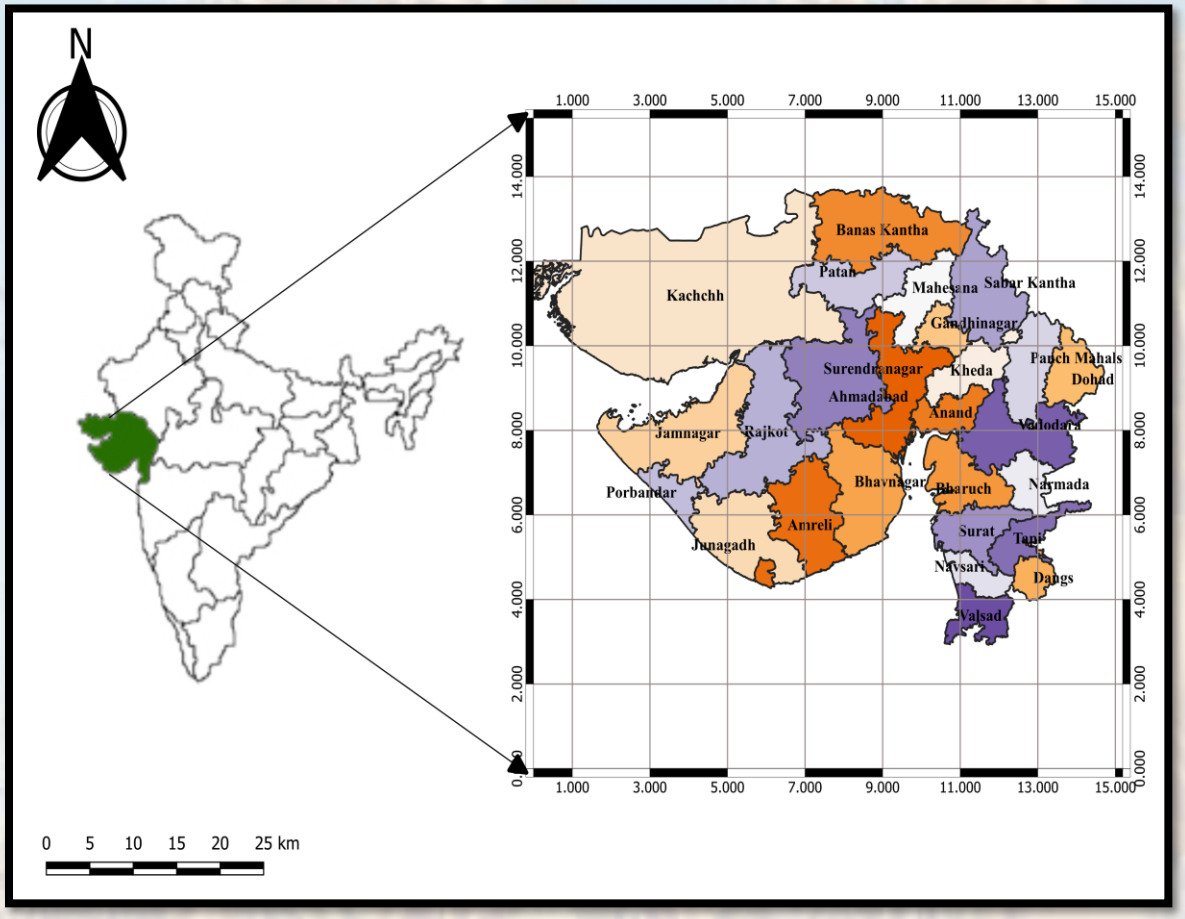
- **Data Source**: Google Earth Engine
- **Season**: Kharif season (July, August, September, October)
- **Area, Yield, Production:** Directorate of Economics and Statistic, Govt. of India

Sr.no.	Dataset	Indices	Period	Resolution
1	Rainfall CHIRPS	PCI	2012-2016	0.05°
2	NDVI MODIS/061/MOD13Q1	VCI	2012-2016	250 Meters
3	LST MODIS/061/MOD11A2	TCI	2012-2016	1000 Meters

Study Area

The study area comprises all districts of Gujarat state, focusing on crop-masked based analysis

- Area: Gujarat has 101 lakh hectare of Net Sown Area and 128 lakh hectare of total cropped Area.



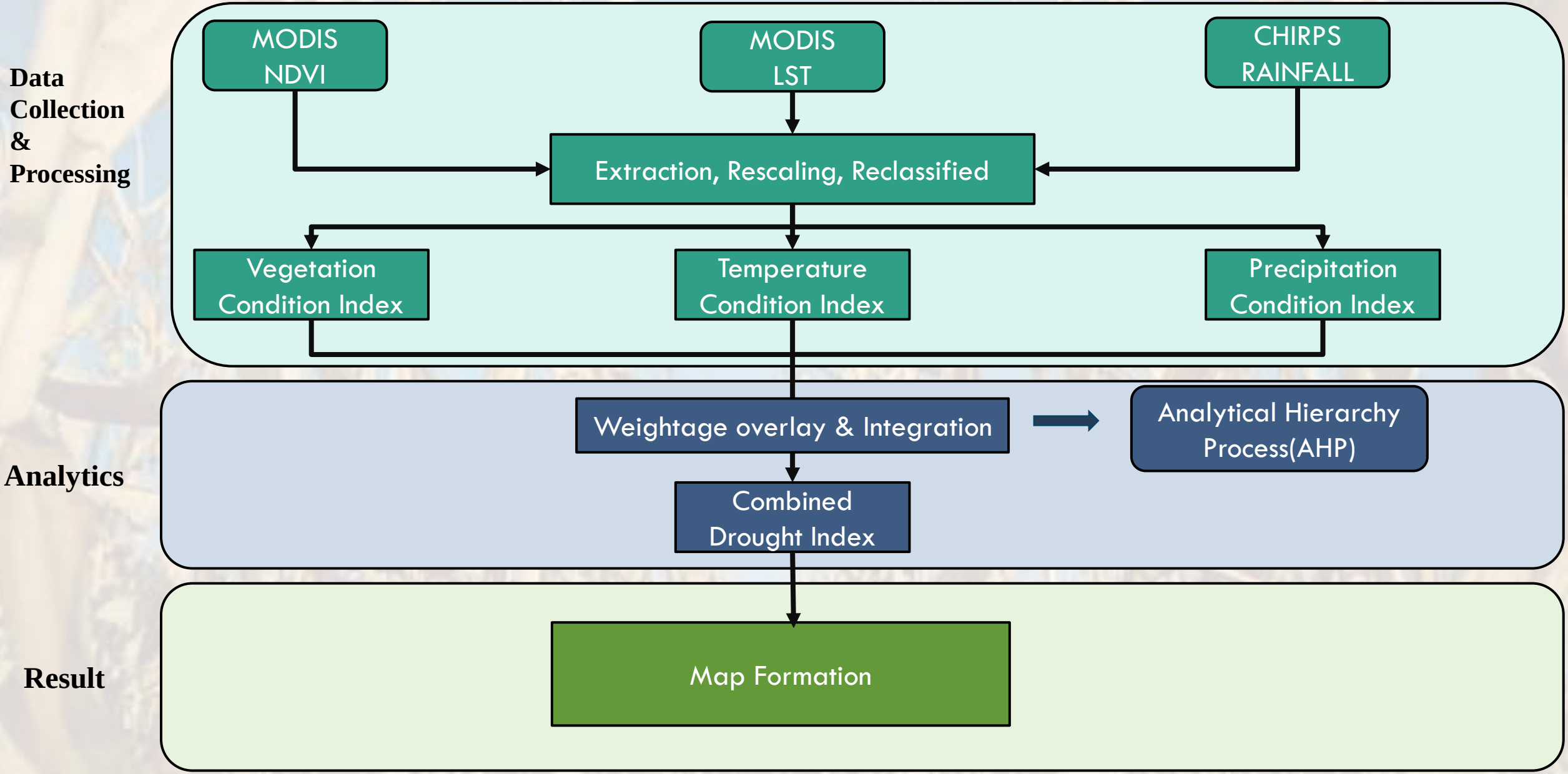
Data

Sr. No	Data	Formula
1	Vegetation Condition Index (VCI)	$\frac{\textbf{(NDVI - NDVImin)}}{\textbf{(NDVImax - NDVImin)}}$
2	Temperature Condition Index (TCI)	$\frac{\textbf{(LSTmax - LST)}}{\textbf{(LSTmax - LSTmin)}}$
3	Precipitation Condition Index (PCI)	$\frac{\textbf{(RF - RFmin)}}{\textbf{(RFmax - RFmin)}}$
4	Combined Drought Index (CDI)	**(α*PCI) + (β*VCI) + (γ*TCI)** ($\alpha = 0.53$, $\beta = 0.33$, $\gamma = 0.14$)
5	Productivity (tonne/ha)	$\frac{\textbf{Total Production}}{\textbf{Area}}$

District wise Productivity Data

YEAR	DISTRICT	TUR_PRO	BAJRA_PRO	COTTON_PRO	GROUNDNUT_PRO	MOONG_PRO	RICE_PRO	SESAMUM_PRO	MAIZE_PRO	TOTAL_PRODUCTION	TOTAL_AREA	OVERALL_PRODUCTIVITY
2011	Ahmadabad	0.9	1.29	1.71	1	0.5	1.97	0.5	0	519100	289800	1.79
2012	Ahmadabad	1.02	1.65	2.48	2.44	0.57	1.89	0.61	1.55	316089	174583	1.81
2013	Ahmadabad	1.09	1.46	3.98	3.68	0.87	2.28	0.4	0	160886	47902	3.36
2014	Ahmadabad	1	1.14	3.61	3.02	0.37	2.01	0.35	1.27	238289	89085	2.67
2015	Ahmadabad	0	0.74	3.18	2.02	0.34	0	0.3	0	186084	62883	2.96
2016	Ahmadabad	1.24	2.03	3.36	2.52	0.57	1.85	0.51	1.6	1397522	434843	3.21
2011	Porbandar	1.11	0.74	2.35	1.84	0.34	1.17	0.11	1.66	194070	117664	1.65
2012	Porbandar	1.44	0	0.56	0.4	0.4	1.13	0.33	1.68	256600	166900	1.54
2013	Porbandar	1.24	1.4	4.28	2.39	0.55	0	0.58	1.55	477750	257525	1.86
2014	Porbandar	1.92	0.87	2.46	0.5	0.46	1.77	0.24	1.65	381000	221800	1.72
2015	Porbandar	1.52	1.7	3.3	1.75	0.51	2.15	0.39	1.45	125643	58555	2.15
2011	Amreli	0.86	1.34	2.05	3.01	0.53	2.34	0.4	0	633392	295427	2.14
2012	Amreli	1	1.52	1.61	0.67	0.27	0	0.18	1.67	609900	439300	1.39
2013	Amreli	1.23	1.5	4.1	4.74	0.82	2.05	0.38	0	142603	43046	3.31
2014	Amreli	1.09	1.11	3.81	1.67	0.36	2.65	0.33	1.25	262881	83982	3.13
2015	Amreli	0	1.02	3.47	1.43	0.36	0	0.23	0	116985	35650	3.28
2016	Amreli	1.09	0	1.26	1.68	0.46	2.61	0	1.56	152500	74000	2.06
2011	Anand	1.09	1.18	1.67	2.03	0.5	2.61	0.59	0	575587	279469	2.06
2012	Anand	0.86	2.51	3.44	2.44	0.69	0	0.7	1.27	1470673	477481	3.08
2013	Anand	1.13	1.41	4.31	3.42	0.55	1.25	0.53	0	128835	43014	3
2014	Anand	1.24	1.3	3.5	2.54	0.4	2.4	0.18	1.32	198130	68378	2.9
2015	Anand	1.14	1.15	3.22	1.64	0.46	0	0.6	0	134875	50840	2.65
2016	Anand	0.62	0	3.17	1.5	0.53	2.61	0.57	1.27	197484	87603	2.25
2013	Aravalli	1.24	1.94	4.18	3.04	0.74	1.25	0.61	1.55	131762	43028	3.06
2014	Aravalli	1.13	1.3	4.26	2.47	0.36	2.36	0.37	1.68	192764	65289	2.95
2015	Aravalli	1.24	0.17	3.36	2.44	0.42	0	0.61	1.55	143025	64710	2.21

Methodology



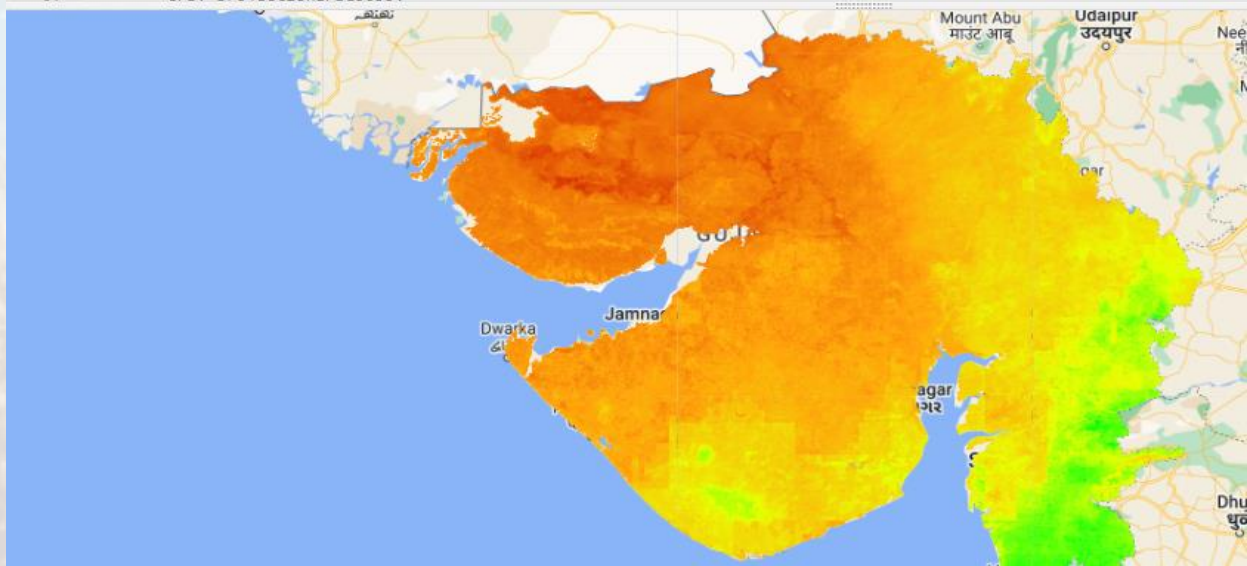
Snippet

MEAN_SDCI * | Get Link | Save | Run | Reset | Apps

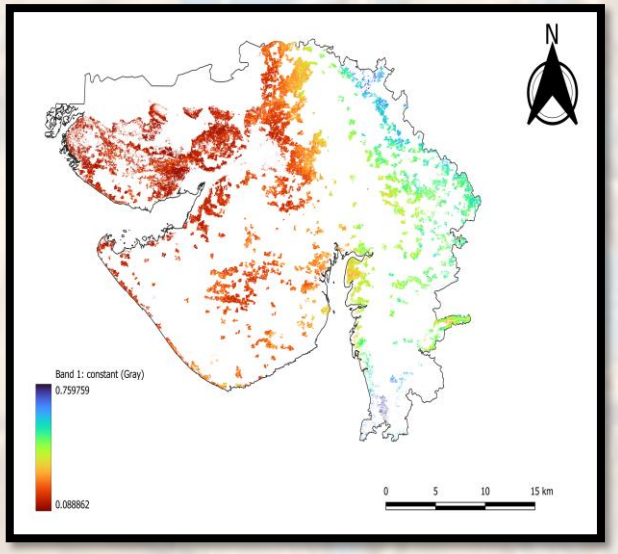
```
Imports (4 entries)
  var table: Table projects/ee-kaushalkathiriya1628/assets/STATE_BOUNDARY
  var NDVI: ImageCollection MODIS/061/MOD13Q1
  var LST: ImageCollection MODIS/061/MOD11A2
  var CHIRPS: ImageCollection "CHIRPS Daily: Climate Hazards Group InfraRed Precipitation With…
// Define exportGeometry globally
var exportGeometry = table.filter(ee.Filter.eq('STATE', 'GUJAR>T'));

// Function to calculate MIDI and SDCI
var indices = function(month, year) {
    // Import the feature collection for administrative boundaries
    var Germany = table.filter(ee.Filter.eq('STATE', 'GUJAR>T'));
    var geometry = Germany.geometry();

    var startDate = ee.Date.fromYMD(year, month, 1);
    var endDate = startDate.advance(1, 'month');

    // NDVI
    var NDVIdataset = NDVI.filter(ee.Filter.date(startDate, endDate));
    var ndvi = NDVIdataset.select('NDVI').mean().clip(geometry);

    // Calculate global min and max for normalization
    var NDVIminMax = ndvi.reduceRegion({
        reducer: ee.Reducer.minMax(),
        geometry: geometry,
        scale: 30,
        maxPixels: 1e13
    });

    var NDVImin = ee.Number(NDVIminMax.get('NDVI_min'));
    var NDVImax = ee.Number(NDVIminMax.get('NDVI_max'));

    // Normalize the NDVI
    var normalizedNDVI = ndvi.expression(
        '(NDVI - min) / (max - min)', {
            'NDVI': ndvi.select('NDVI'),
            'min': NDVImin,
            'max': NDVImax
        }).rename('VCI');

    // LST
    var LSTdataset = LST.filter(ee.Filter.date(startDate, endDate));
    var landSurfaceTemperature = LSTdataset.select('LST_Day_1km').mean().subtract(273.15).clip(geometry);

    // Calculate global min and max for normalization
    var LSTminMax = landSurfaceTemperature.reduceRegion({
        reducer: ee.Reducer.minMax(),
        geometry: geometry,
        scale: 30,
        maxPixels: 1e13
    });

    var LSTmin = ee.Number(LSTminMax.get('LST_Day_1km_min'));
    var LSTmax = ee.Number(LSTminMax.get('LST_Day_1km_max'));

```

MEAN_SDCI * | Get Link | Save | Run | Reset | Apps

```
        geometry: geometry,
        scale: 30,
        maxPixels: 1e13
    });

    var PPTmin = ee.Number(PPTminMax.get('precipitation_min'));
    var PPTmax = ee.Number(PPTminMax.get('precipitation_max'));

    // Normalize the Precipitation
    var normalizedPrecipitation = precipitation.expression(
        '(precipitation - min) / (max - min)', {
            'precipitation': precipitation.select('precipitation'),
            'min': PPTmin,
            'max': PPTmax
        }).rename('PCI');

    var indices = normalizedNDVI.addBands(normalizedLST).addBands(normalizedPrecipitation);

    // CDI
    var CDI = indices.expression(
        'a * TCI + b * PCI + (1 - a - b) * VCI', {
            'TCI': indices.select('TCI'),
            'PCI': indices.select('PCI'),
            'VCI': indices.select('VCI'),
            'a': 0.25,
            'b': 0.5
        });

    var projectionEPSG3035 = 'EPSG:4326';

    var Resampled_CDI = CDI.reproject({
        crs: projectionEPSG3035,
```



Kharif Season CDI (2012)



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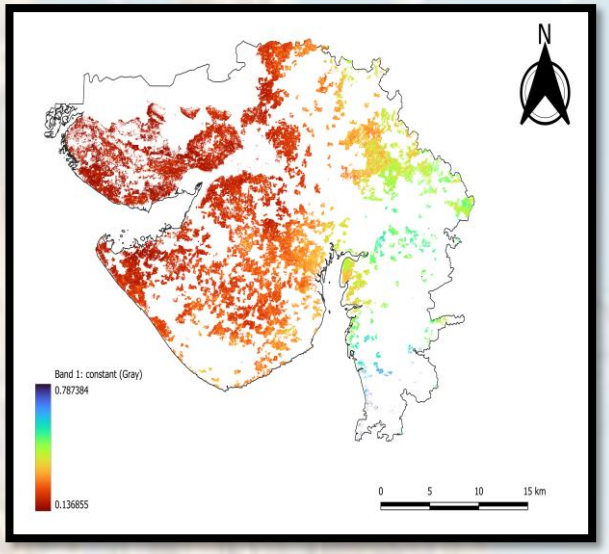

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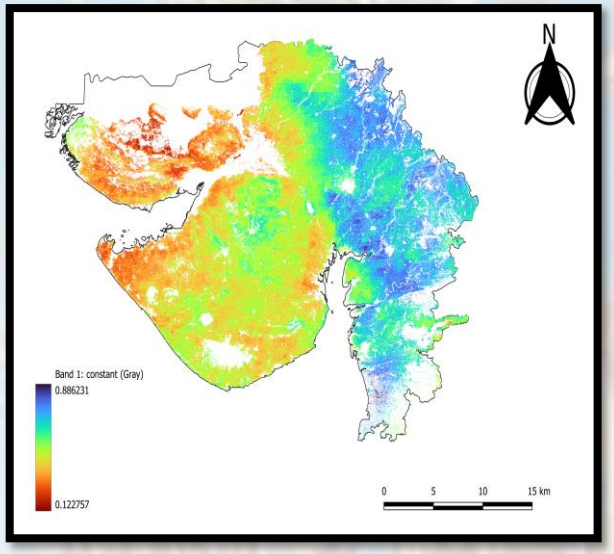

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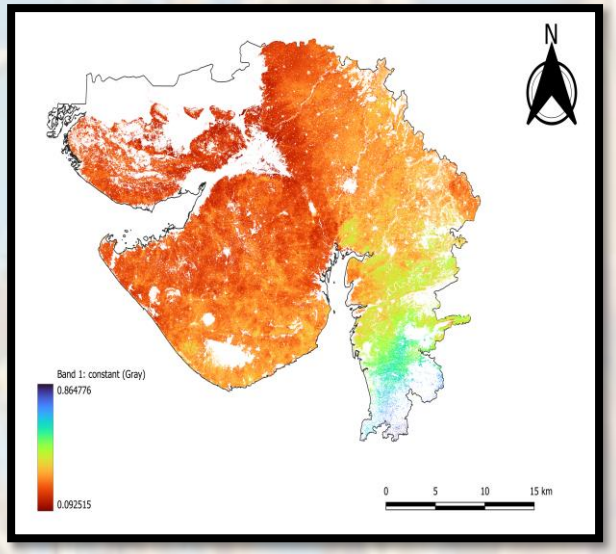
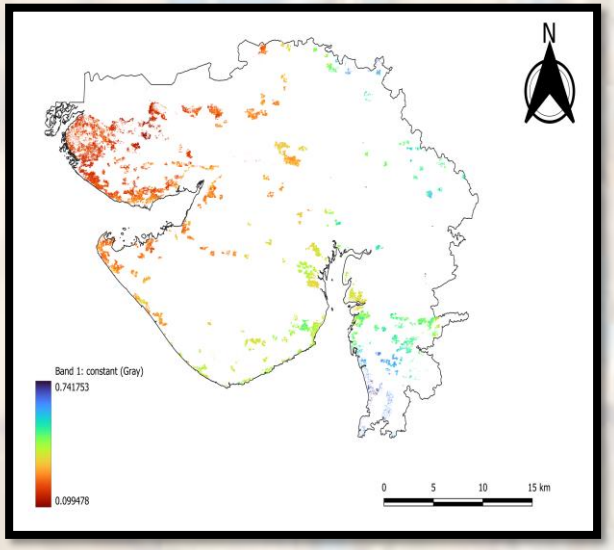


OCT_2012

Kharif Season CDI (2013)



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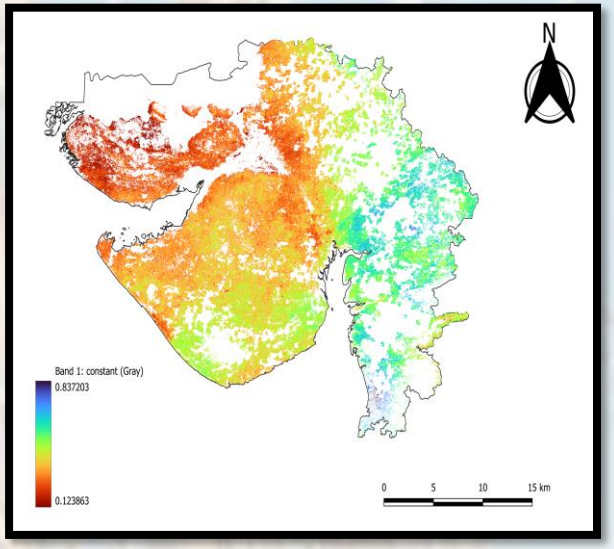

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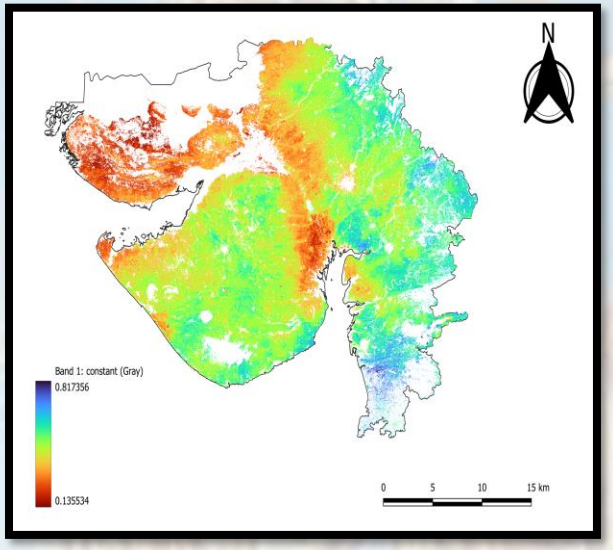

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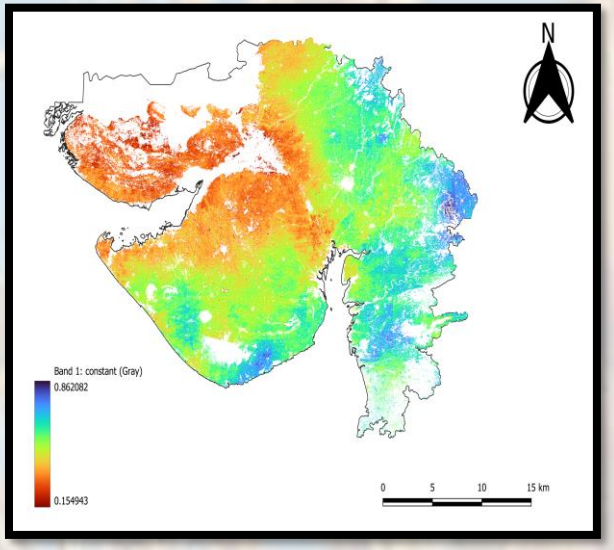
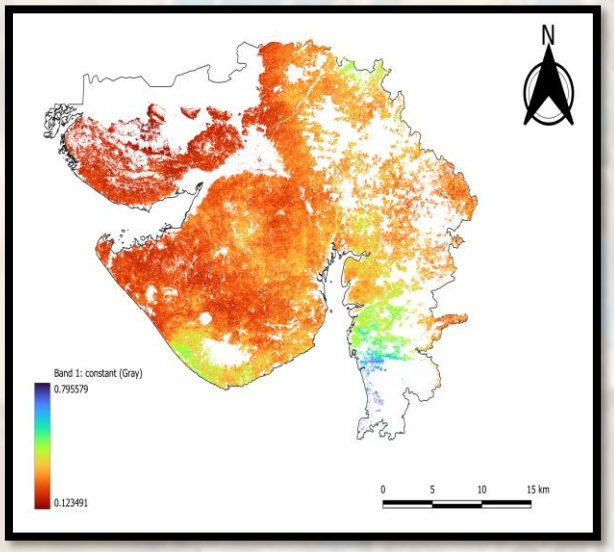


OCT_2013

Kharif Season CDI (2014)



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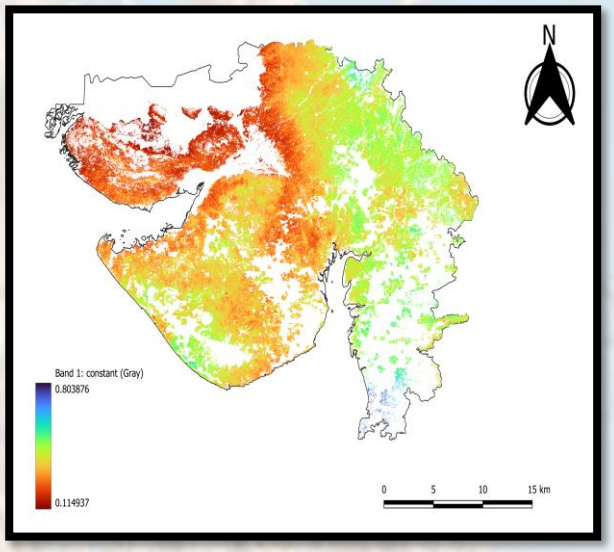

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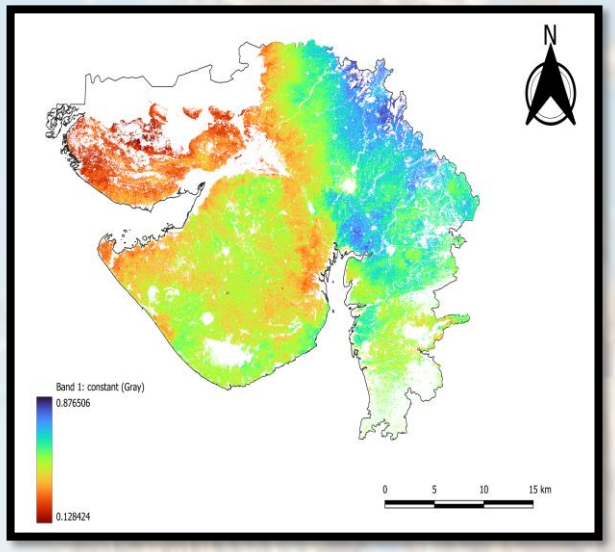

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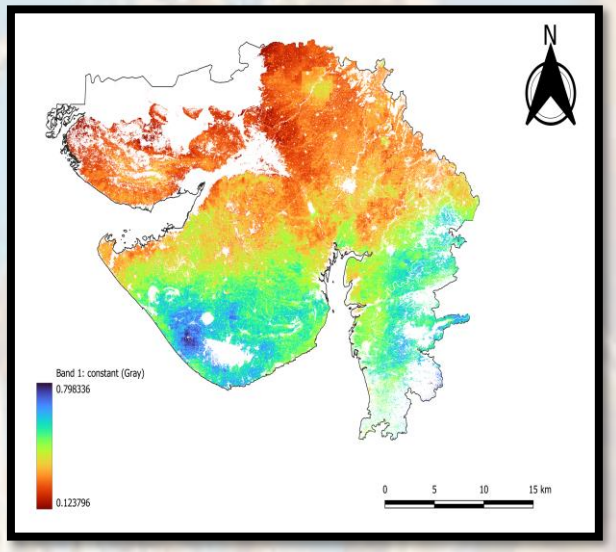
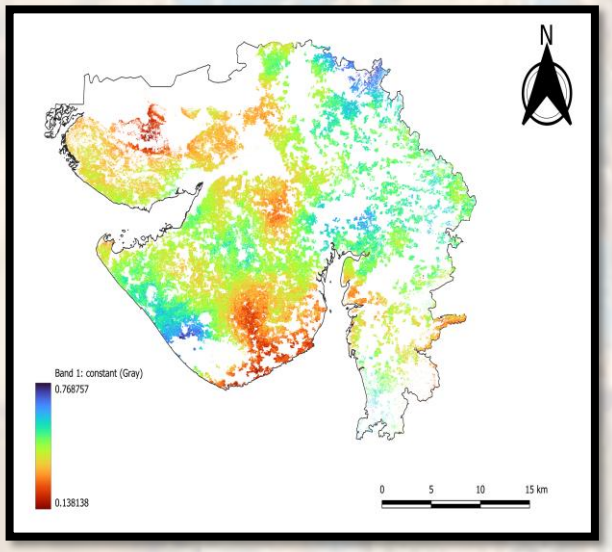


OCT_2014

Kharif Season CDI (2015)



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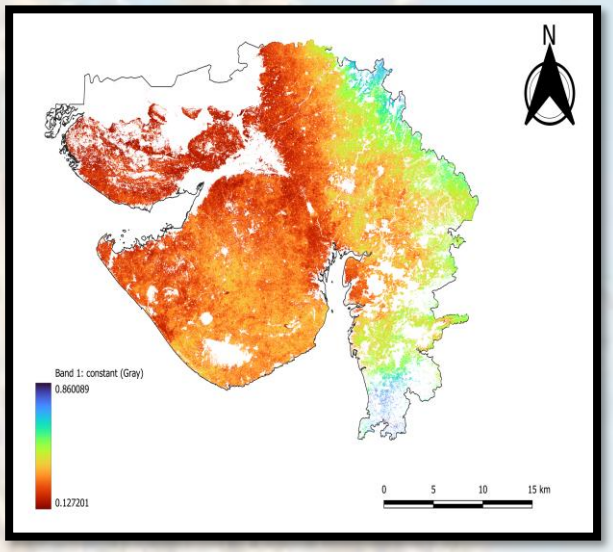

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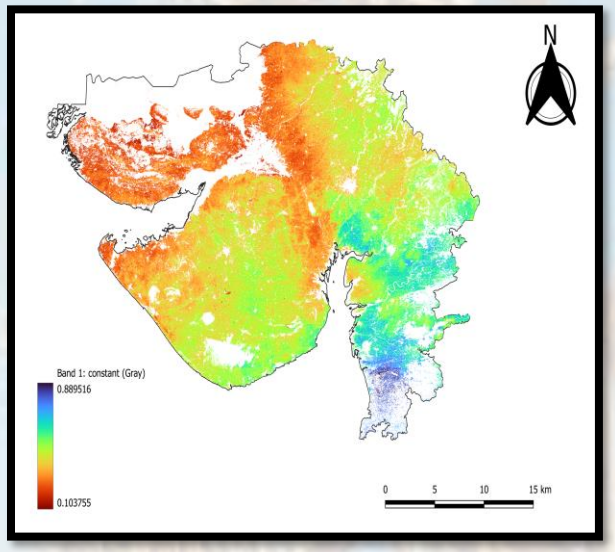

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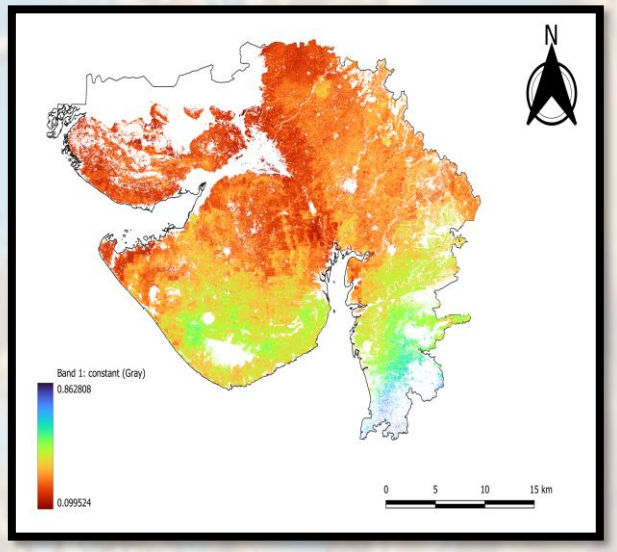
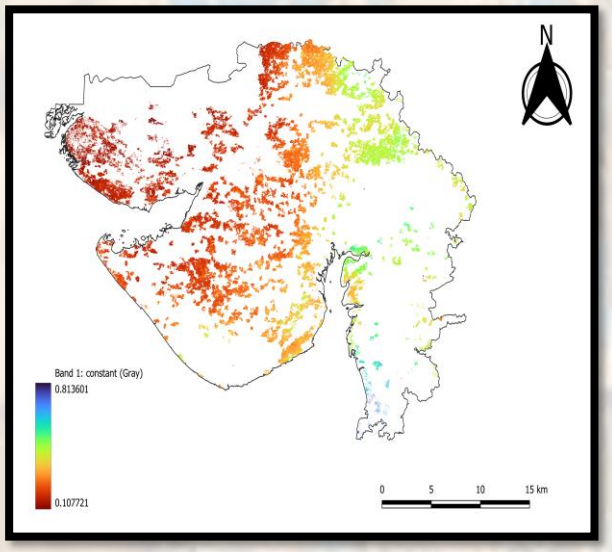


OCT_2015

Kharif Season CDI (2016)



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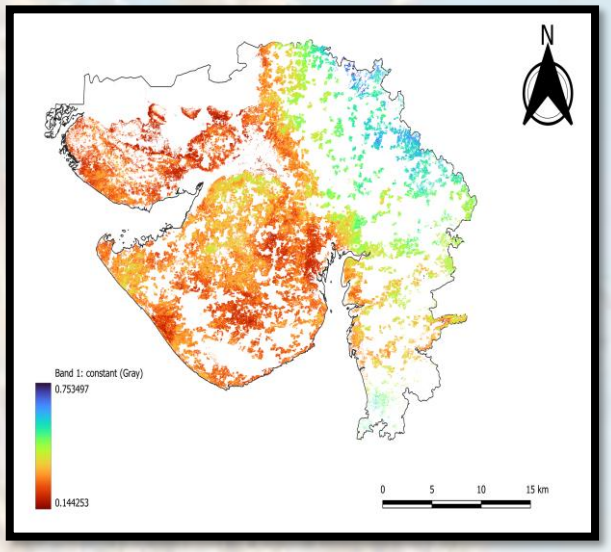

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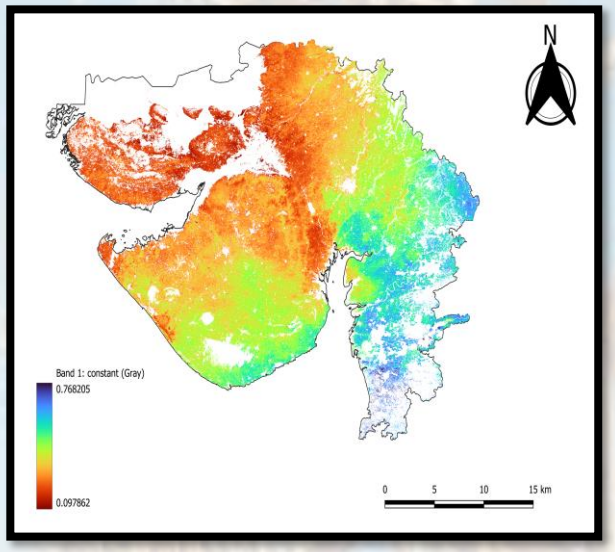

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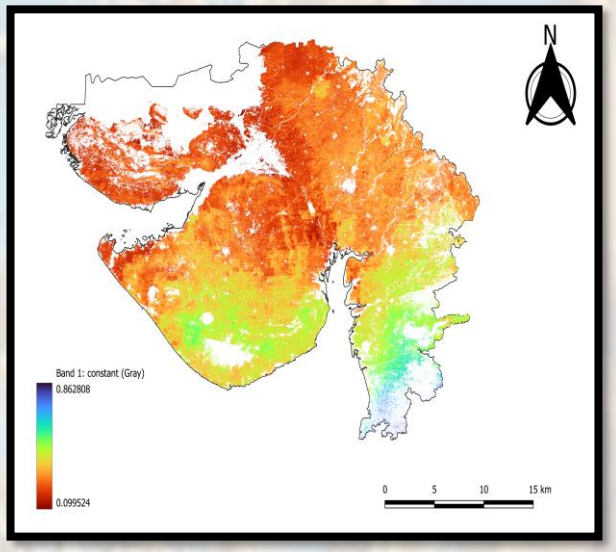
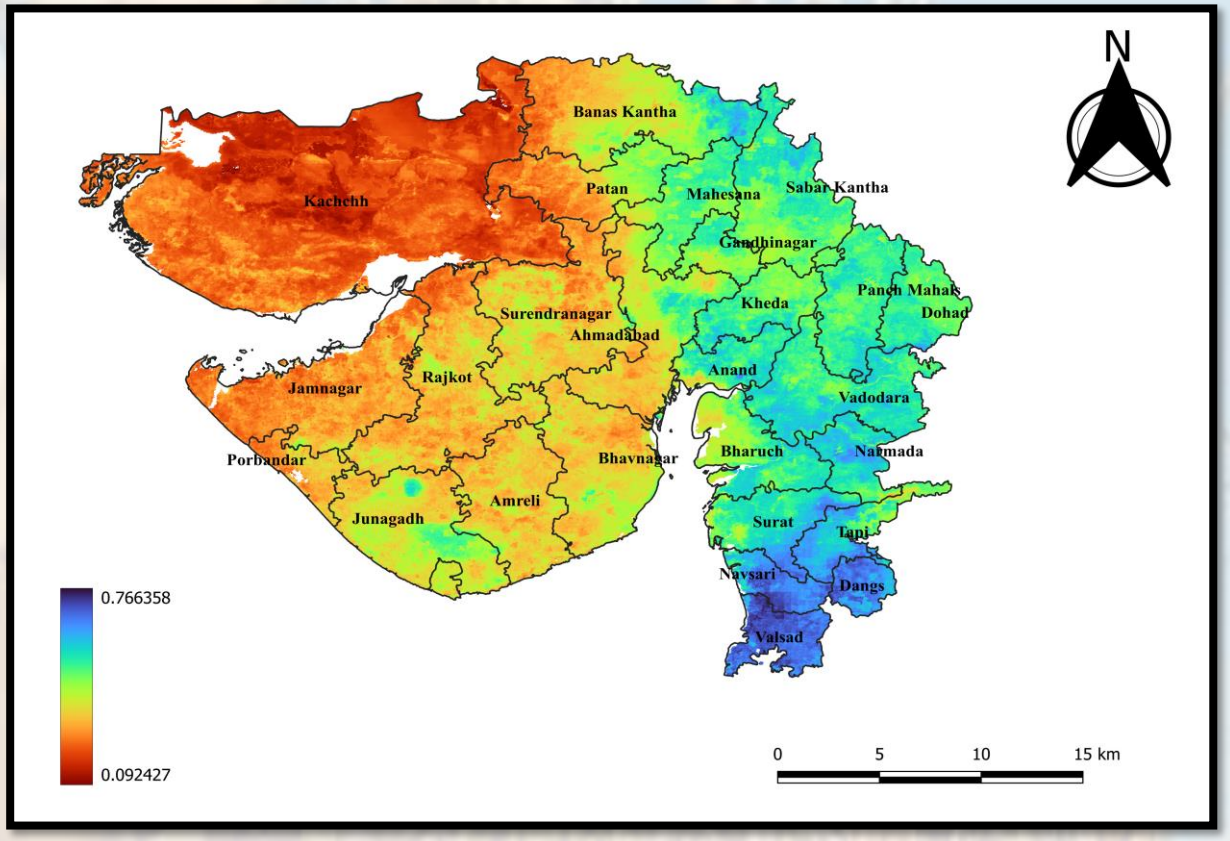
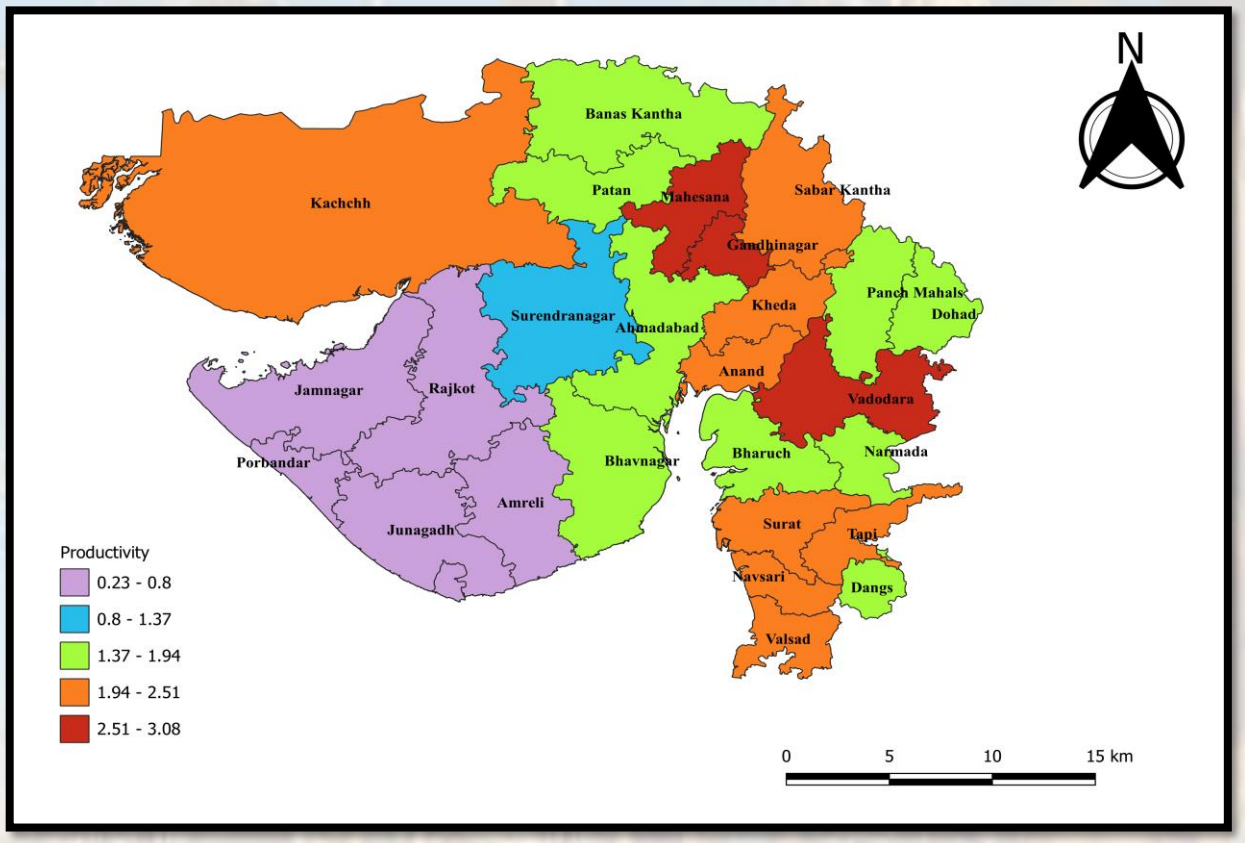


OCT_2016

Drought's Effect on Crop Productivity (2012)

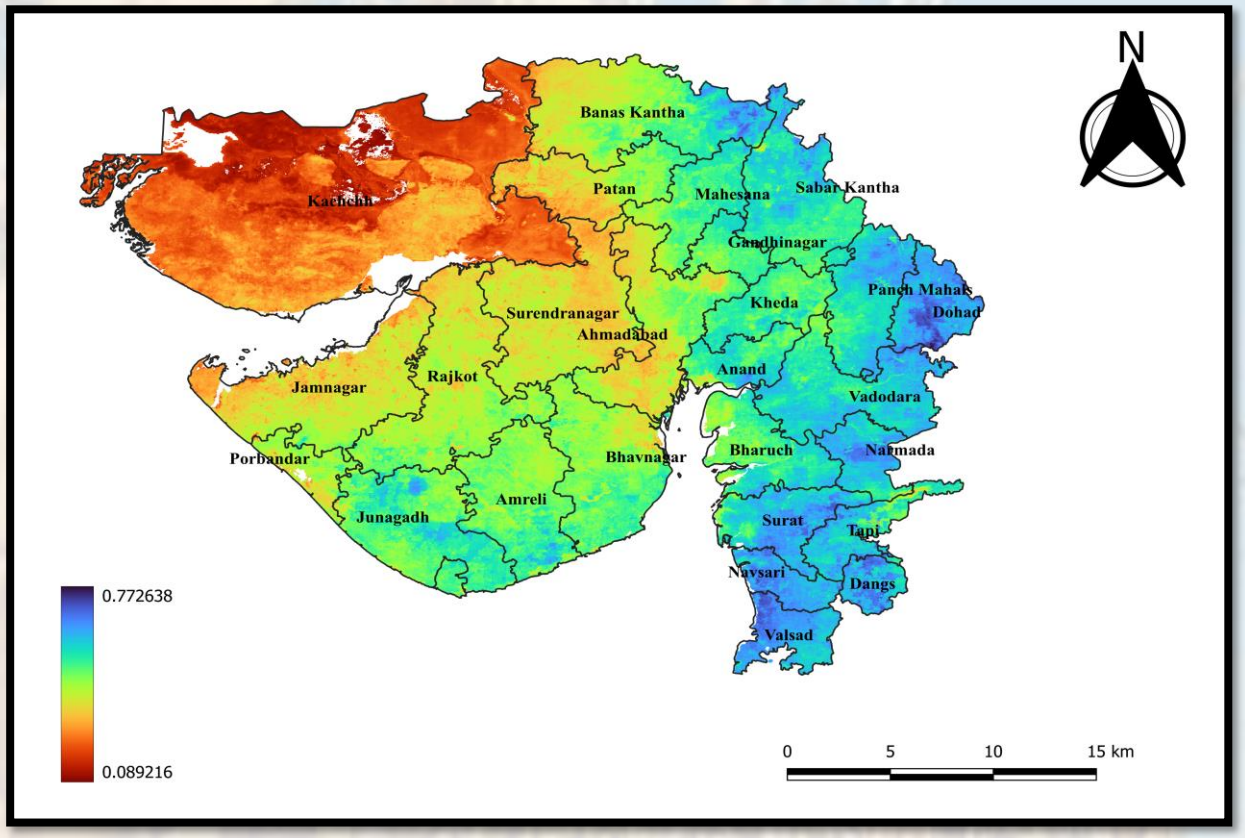


Combined Drought Index Map

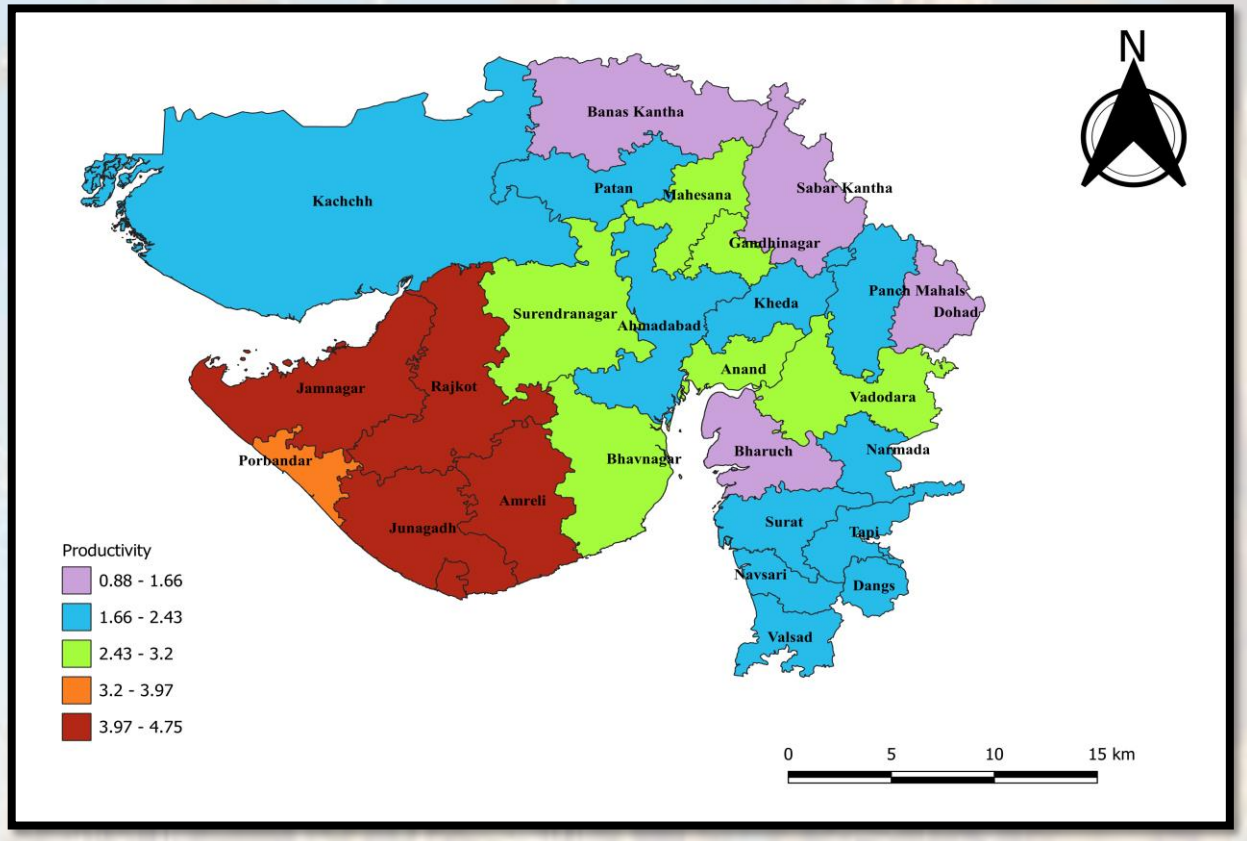


Productivity Map

Drought's Effect on Crop Productivity (2013)

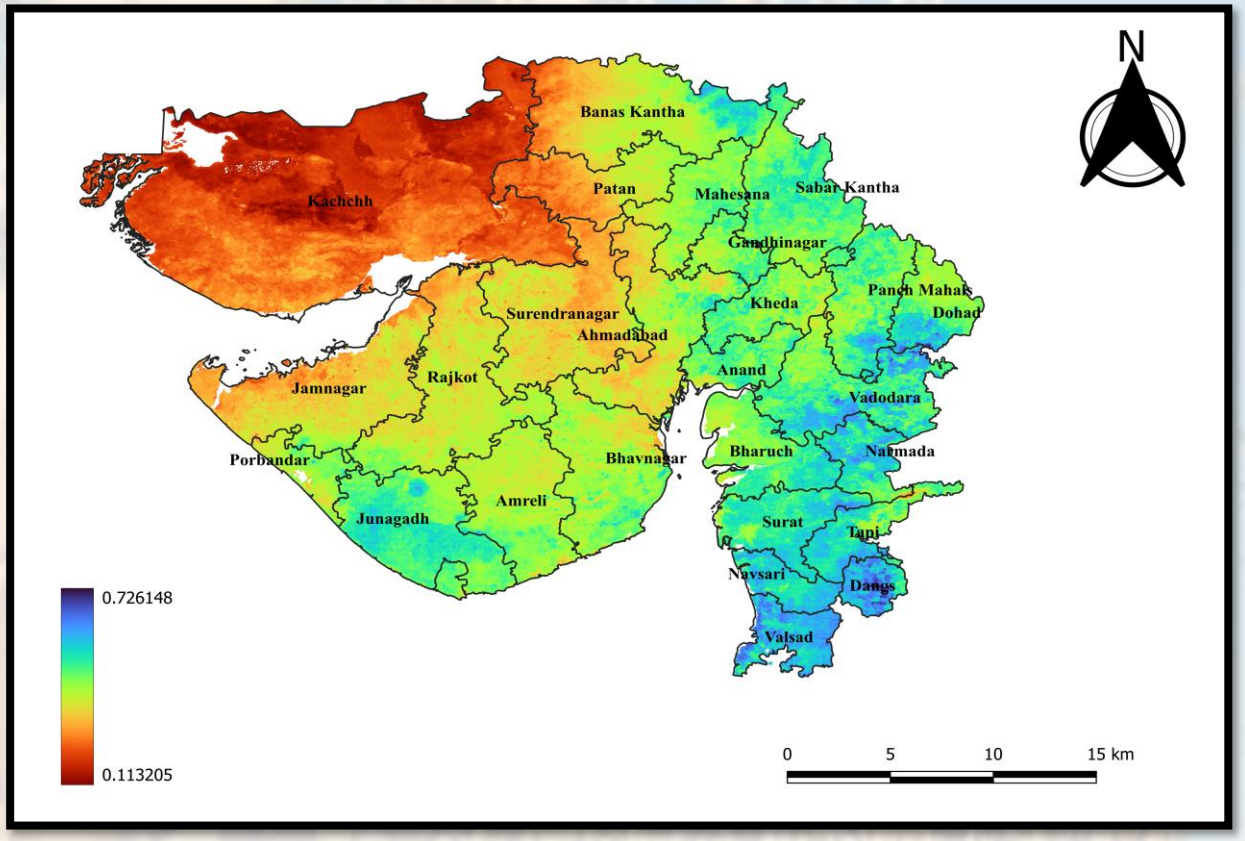


Combined Drought Index Map

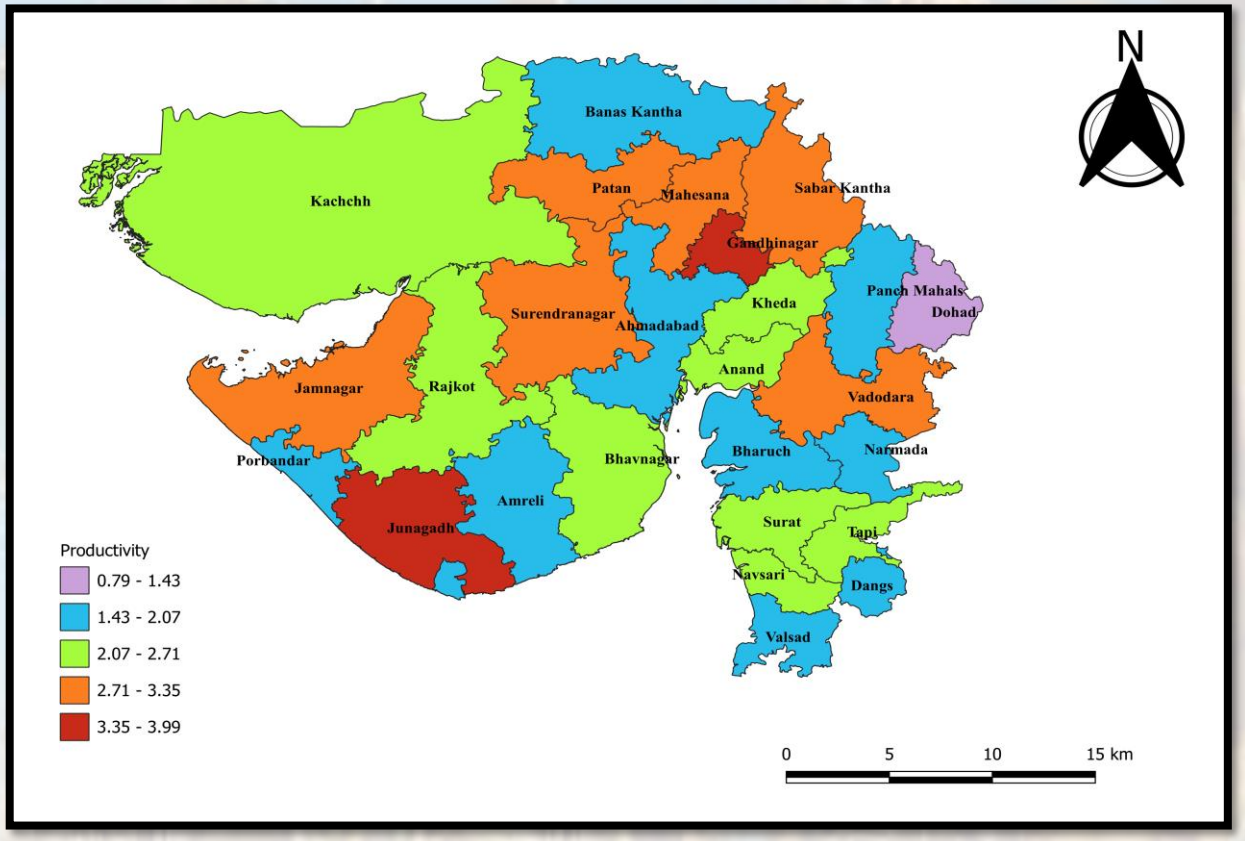


Productivity Map

Drought's Effect on Crop Productivity (2014)

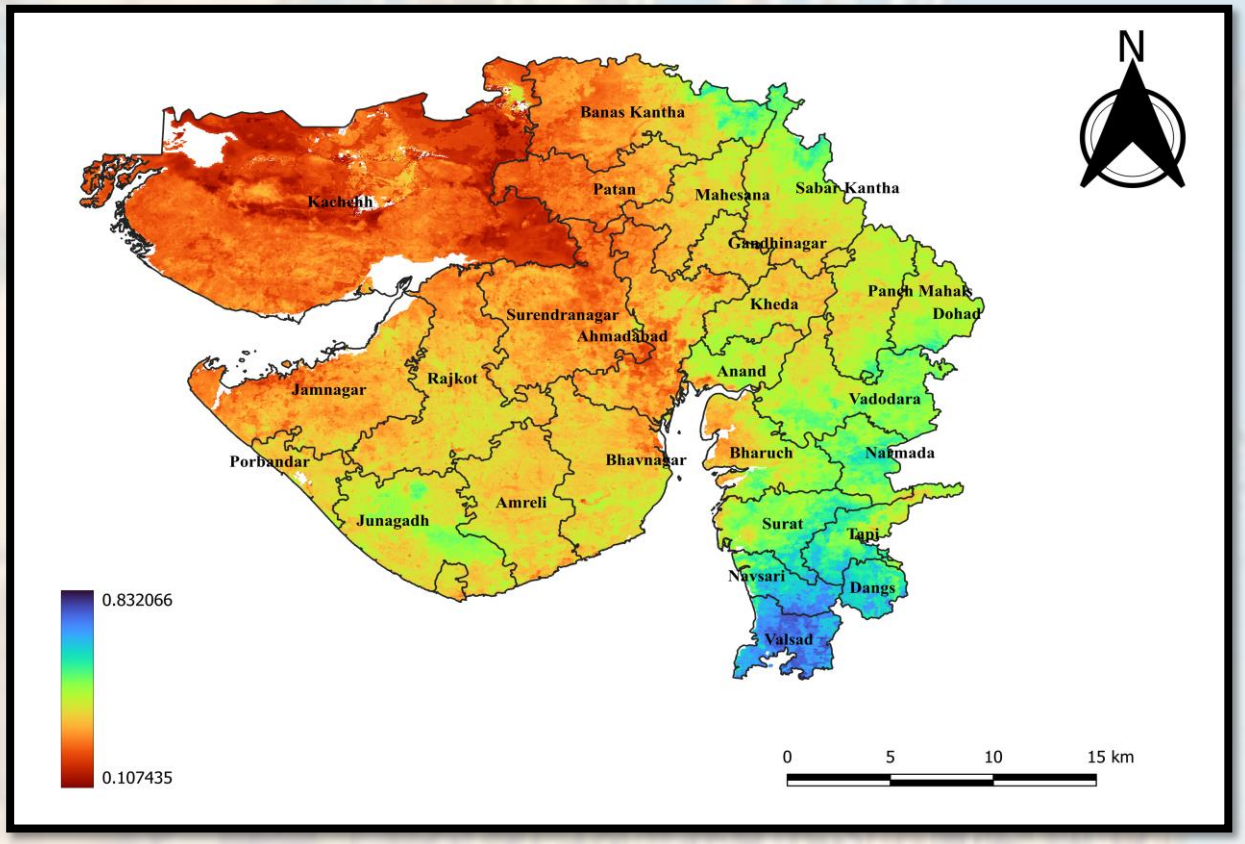


Combined Drought Index Map

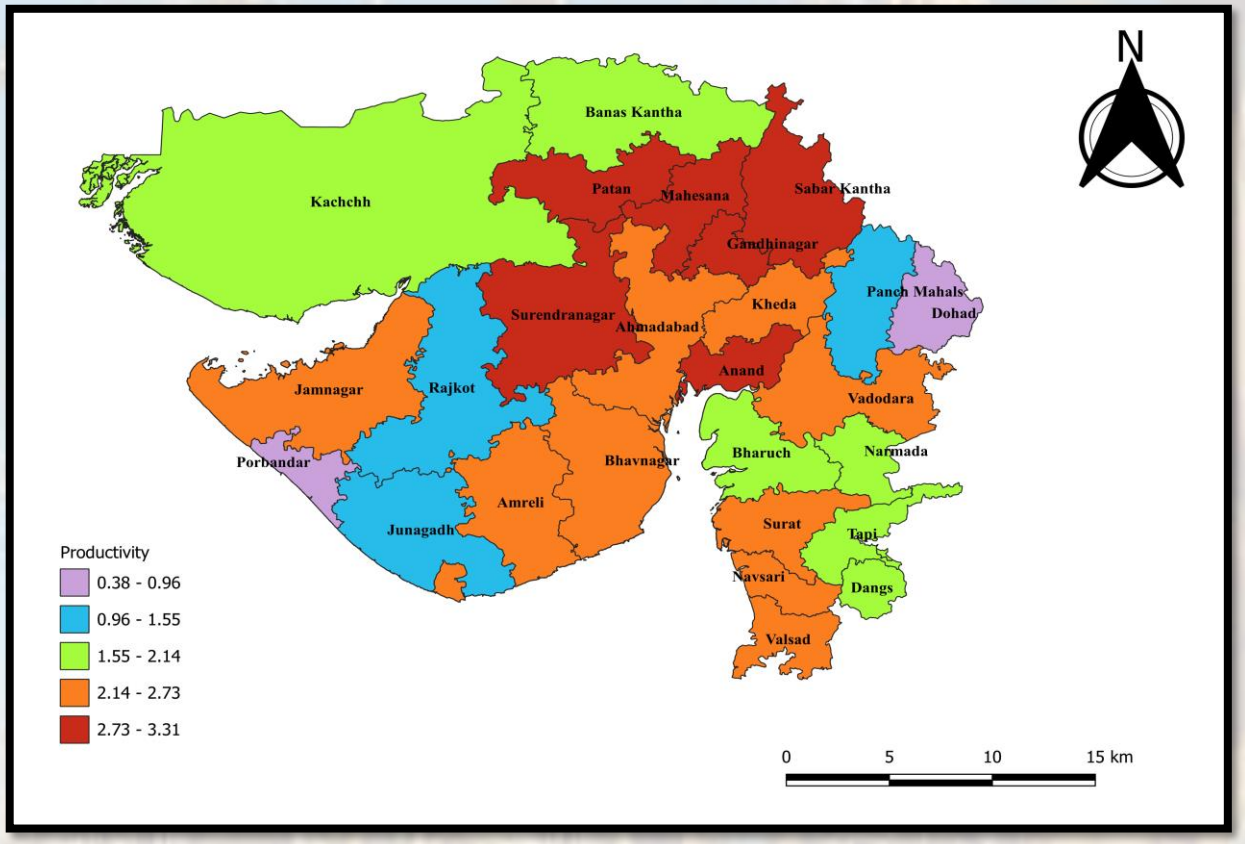


Productivity Map

Drought's Effect on Crop Productivity (2015)

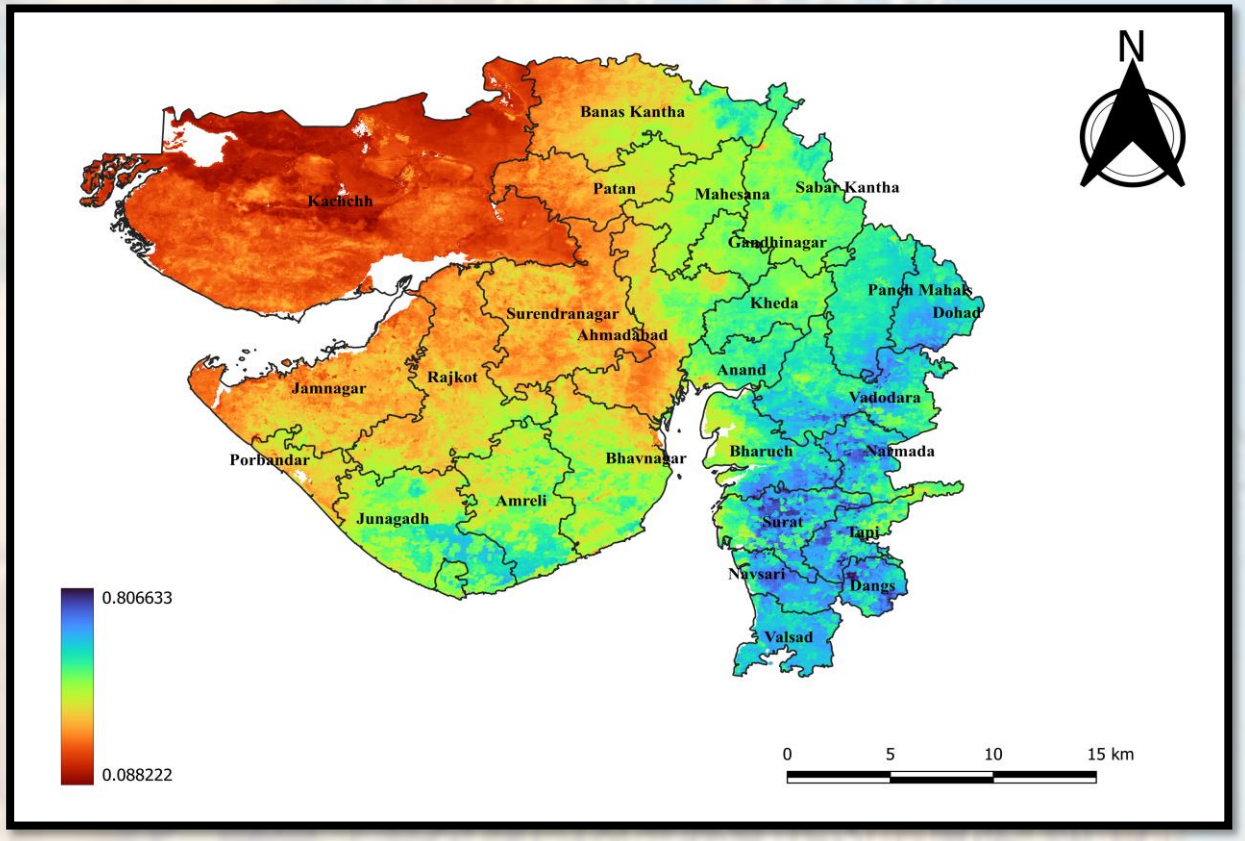


Combined Drought Index Map

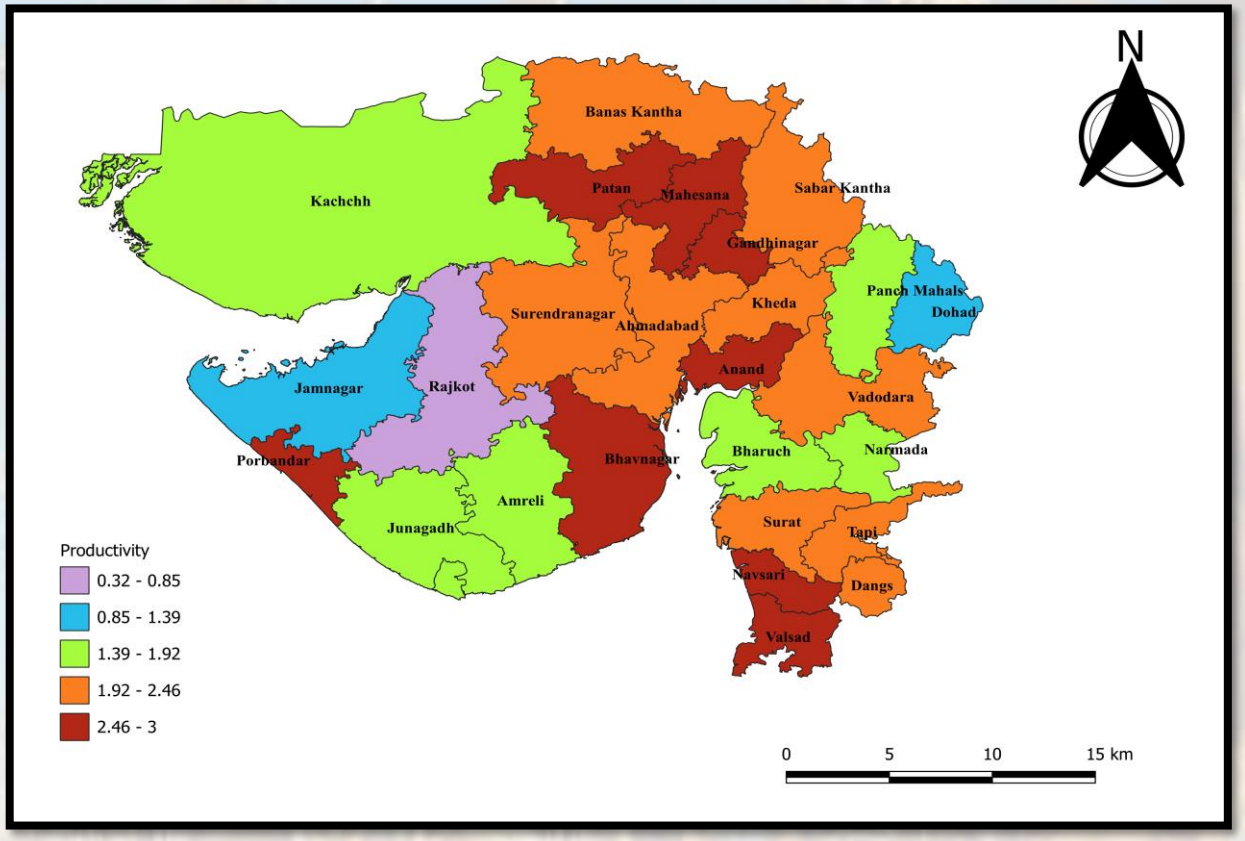


Productivity Map

Drought's Effect on Crop Productivity (2016)



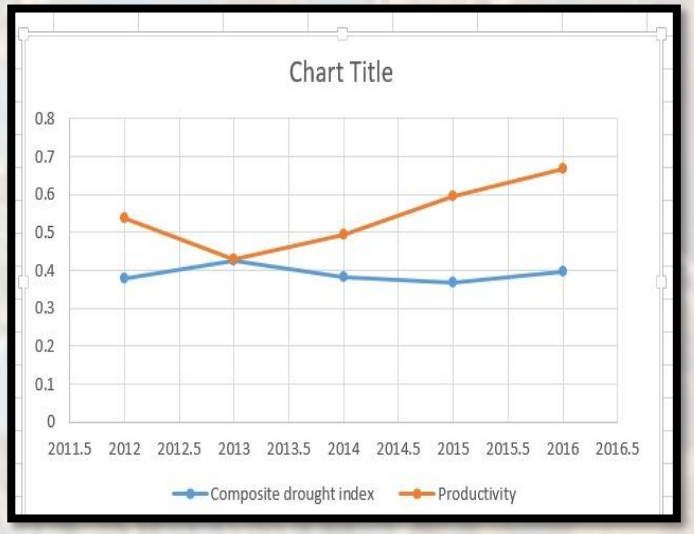
Combined Drought Index Map



Productivity Map

Conclusion

- As the Composite Drought Index remains relatively stable, with a slight increase from 2012 to 2016, the productivity trend rises consistently.
- This may indicate that despite mild drought conditions, productivity improved over time, possibly due to better agricultural practices, water management, or crop resilience.
- The notable decline in productivity in 2013 coinciding with a stable drought index could point to other external factors affecting crop yields during that period.
- Overall, the upward trend in productivity suggests resilience or adaptation in the agricultural sector over these years.




Thank you