P1: MAPPING WATER BODIES USING NDWI

Submitted by

Saumya Kukreti

Student, Masters of Technology

Indian Institute of technology Kanpur

Date: 16.08.2025

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Mapping Surface Water Bodies using the Normalized Difference Water Index (NDWI) from Satellite Imagery

Objective: To identify and delineate surface water bodies using the Normalized Difference Water Index (NDWI) from satellite imagery.

Study Area:

Chilika Lake, located along the eastern coast districts three districts in the state of Odisha namely Puri, Khordha, and Ganjam of India in Odisha spanning approximately 19°28′–19°54′ N and 85°05′–85°38′ E, is a dynamic brackish-estuarine coastal lagoon formed behind a Pleistocene barrier spit that evolved as sea levels rose around 6,000–8,000 years ago. Geological evidence, including optically stimulated luminescence dating of sediments, suggests that the prominent barrier developed over the last few centuries, with deposition rates increasing sharply within the past 300 years, coinciding with shifts in longshore drift and coastal processes.

The lagoon exhibits significant seasonal variation in water-spread area from roughly 900 km² in the dry season to approximately 1,165 km² during the monsoon, with a shallow average depth of 1.7 to 3.7 m. It stretches about 64 km in length and up to 32 km in width, connected to the Bay of Bengal via a 32 km outer channel. Several islands and marshy spits divide the lagoon, contributing to diverse ecological habitats.

The lagoon basin consists of mixed substrates—rock, sand, silt, clay, gravel, and shell deposits—with silt dominating much of the catchment, while the Daya River and numerous rivulets supply 1.5–1.6 million metric tons of sediment annually. Its western and southern margins are flanked by the Eastern Ghats, characterized by Proterozoic charnockite–khondalite complexes and prominent igneous intrusions such as the Balugaon anorthosite.

From a remote sensing perspective, Chilika Lake has been extensively analyzed using archival optical satellite data to assess long-term changes. NDWI derived from Landsat 5–TM and Landsat 8–OLI imagery indicates an average annual water-spread reduction of ~1.5 km², totaling about 14.7 km² between 1988 and 2017. Land-cover studies (1987–2016) show decreases in bare ground, grassland, and open water, along with increases in shrub and forest cover, suggesting ecological succession and possible human influence. Multi-sensor approaches have also been used to monitor total suspended sediments (TSS) and phytoplankton biomass (chlorophyll-a), providing insight into sediment dynamics and biological productivity. Recent methods leveraging Google Earth Engine and spectral indices such as NDTI, NDCI, and TSS enable automated, efficient mapping of water quality and opticalparameters.

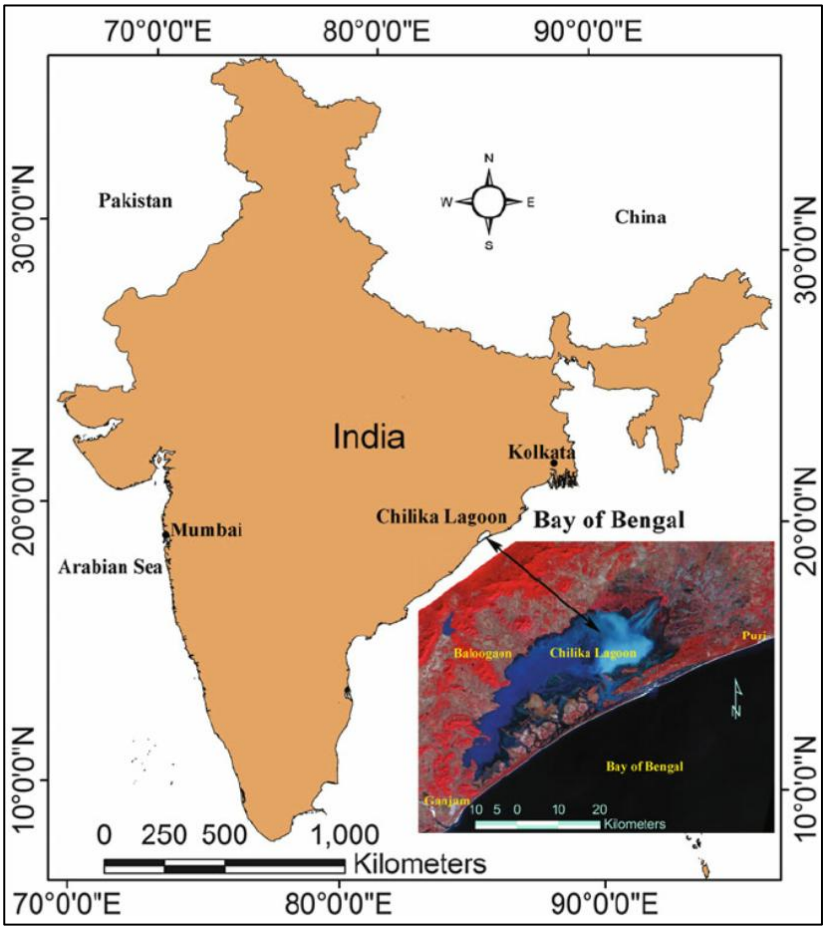


Figure 1: location of Chilika lagoon and its adjacent areas.

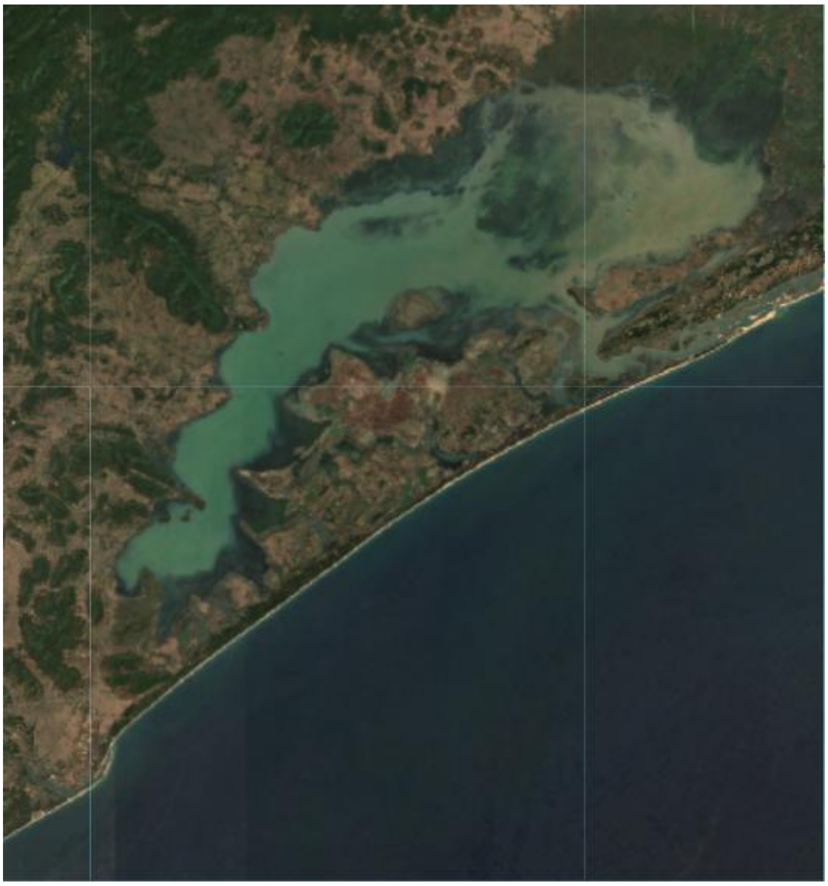


Figure 2:Study area using Sentinel-2

Data Used: surface reflectance-Level-2A orthorectified atmospherically corrected surface reflectance (data used)

Satellite Imagery: Sentinel-2

URL: ee. Image Collection("COPERNICUS/S2_SR_HARMONIZED")

Downloaded Imagery from: Sentinel-2

Reference: GEE

Band: Band 3 and Band 8

Date Range: 1st Jan 2024- 31st Dec 2024

Methodology:

Mark AOI (Jan 2024 – Dec 2025) using shapefile tools.

Mask clouds (<10%) and classify pixels with NDWI > 0 as water.

```
var aoi = ee.Geometry.Polygon([
  [
    [85.015, 19.310], // SW corner
    [85.015, 19.900], // NW
    [85.600, 19.900], // NE
    [85.600, 19.310]  // SE
  ]
]);
```

```
var start = '2024-01-01';  // clear water season
var end   = '2024-12-31';
var maxCloud = 10;         // % cloud filter for collection
var ndwiThreshold = 0.0;   // NDWI > 0 for water
```

Process Sentinel bands 3 and 8 in Google Earth Engine to compute NDWI.

```
function maskS2clouds(img) {
  var scl = img.select('SCL');
  // Mask out unwanted classes
  var mask = scl.neq(3)  // cloud shadow
              .and(scl.neq(8))  // medium cloud
              .and(scl.neq(9))  // high cloud
              .and(scl.neq(10)) // thin cirrus
              .and(scl.neq(11)); // snow/ice
  return img.updateMask(mask)
          .divide(10000)
          .copyProperties(img, img.propertyNames());
}
```

Loading sentinel image using in built google earth engine.

```
var s2 = ee.ImageCollection('COPERNICUS/S2_SR_HARMONIZED')
  .filterBounds(aoi)
  .filterDate(start, end)
  .filter(ee.Filter.lt('CLOUDY_PIXEL_PERCENTAGE', maxCloud))
  .map(maskS2clouds);

var image = s2.median().clip(aoi);
```

```
var waterVectors = water.rename('water').reduceToVectors({
  geometry: aoi,
  scale: 10,
  geometryType: 'polygon',
  eightConnected: true,
  labelProperty: 'water',
  maxPixels: 1e13
});

waterVectors = waterVectors.map(function (f) {
  var areaSqKm = f.geometry().area({maxError: 1}) / 1e6;
  var meanNdwi = ndwi.reduceRegion({
    reducer: ee.Reducer.mean(),
    geometry: f.geometry(),
    scale: 10,
    maxPixels: 1e13
  }).get('NDWI');
  return f.set({
    'area_sqkm': areaSqKm,
    'mean_ndwi': meanNdwi
  });
});

var outlines = ee.Image().byte().paint(waterVectors, 0, 2);
Map.addLayer(outlines, {palette:['00FFFF']}, 'Water Polygons');
```

```
var totalWaterArea = water.multiply(ee.Image.pixelArea()).reduceRegion({
  reducer: ee.Reducer.sum(),
  geometry: aoi,
  scale: 10,
  maxPixels: 1e13
});
print('Total water area (sq. km):',
      ee.Number(totalWaterArea.get('NDWI')).divide(1e6));
```

Convert water pixels to vector layers, compute area metrics, and export outputs.

```
Export.image.toDrive({
  image: water,
  description: 'Chilika_Water_Mask_NDWI_2024',
  fileNamePrefix: 'Chilika_Water_Mask_NDWI_2024',
  region: aoi,
  scale: 10,
  maxPixels: 1e13
});

Export.table.toDrive({
  collection: waterVectors,
  description: 'Chilika_Water_Polygons_2024',
  fileFormat: 'SHP'
});
```

Results:

- Raster layers distinguishing water and non-water zones

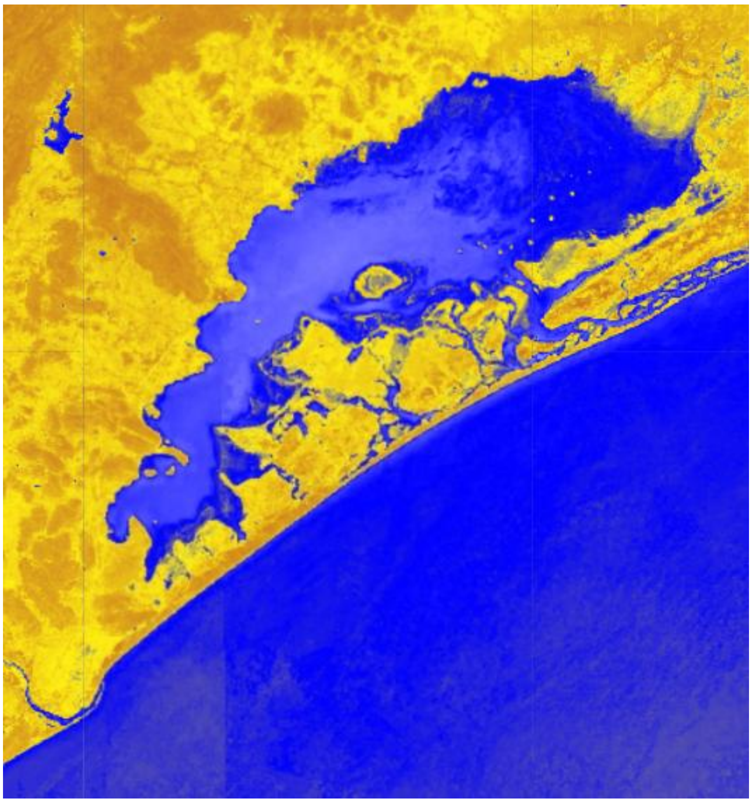
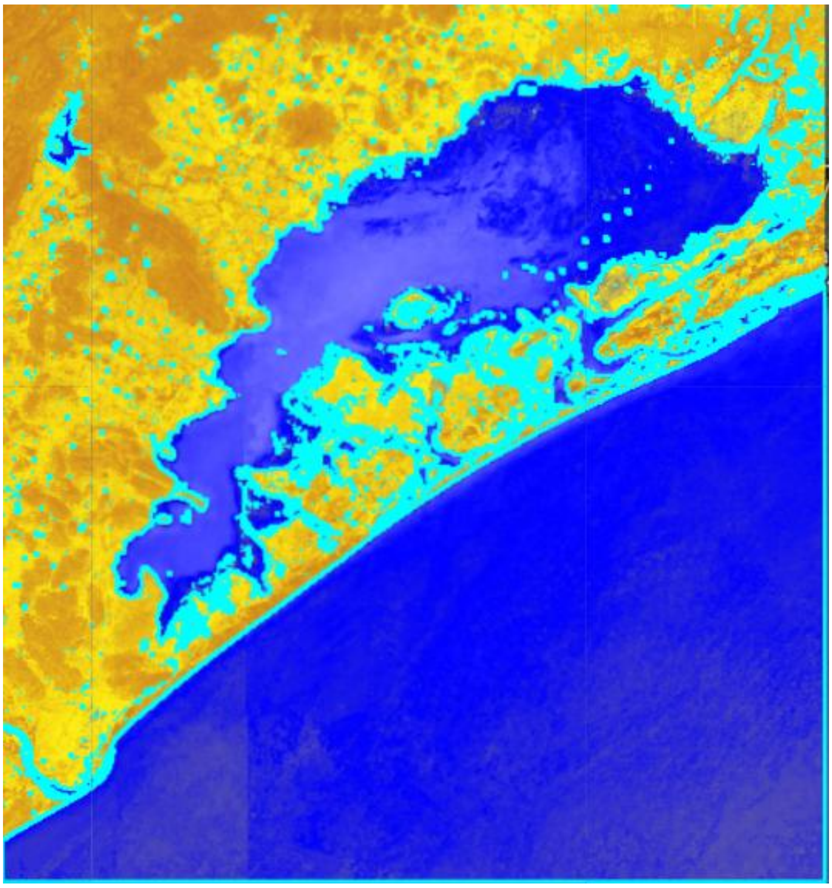


Figure 3:NDWI

Figure 4:Water Masking



- Vector features outlining water boundaries.

Figure 5:Water Polygon

- Total area calculations of water body.

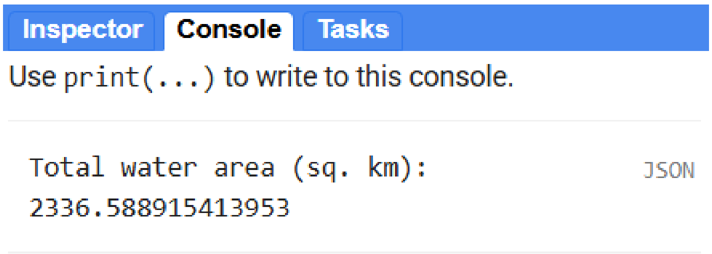


Figure 6:Total area calculation

- Final maps prepared with standardized legends and labelling.

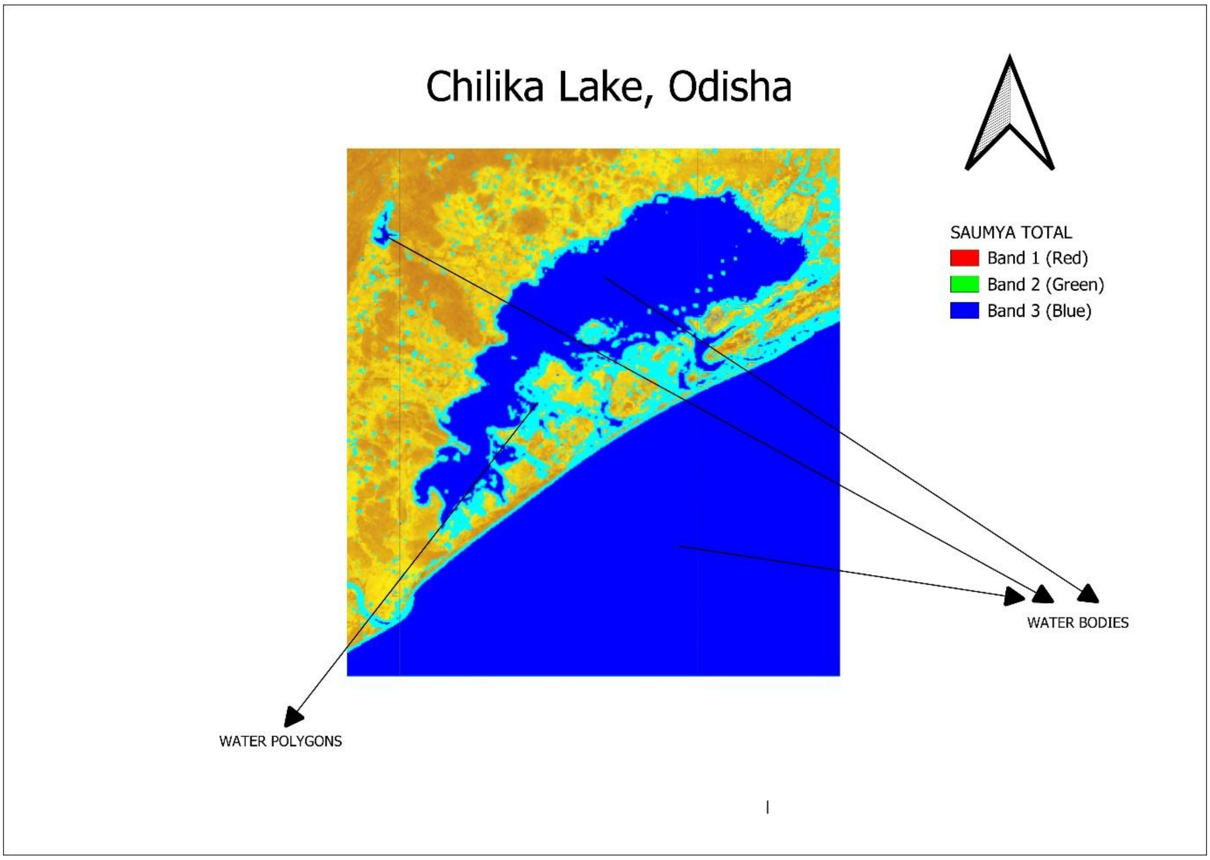


Figure 7 : Final labelled map

Conclusion:

The NDWI method effectively highlights surface water using the difference in reflectance between the green and NIR bands. It is a fast, reliable, and replicable method using freely available satellite data. However, limitations include: Misclassification of shadows, built-up areas, or flooded vegetation as water. Seasonal variation affecting water levels. Sensitivity to image cloud cover and resolution. Despite limitations, NDWI remains an essential tool for hydrological and environmental assessments