**README: Damodar River Sand Mining Detection using Google Earth Engine**

**Introduction**

This project utilizes **Google Earth Engine (GEE)** to detect potential sand mining hotspots along the **Damodar River**. The analysis leverages satellite imagery from the **Landsat 8 Collection 2 (Level 2)** dataset, combined with multiple spectral indices and probability modeling to identify areas susceptible to illegal sand mining activities.

**Objectives**

The goal of this script is to:

1. Load the Damodar River shapefile and generate a 1 km buffer around it.
2. Load and preprocess Landsat 8 imagery for the year 2023.
3. Compute key spectral indices:
   * **NDWI** (Normalized Difference Water Index)
   * **NDVI** (Normalized Difference Vegetation Index)
   * **MNDWI** (Modified Normalized Difference Water Index)
   * **BSI** (Bare Soil Index)
4. Develop a sand mining probability model using these indices.
5. Conduct a temporal analysis by comparing 2023 data with 2018 historical imagery.
6. Visualize the probability of sand mining activities and highlight significant hotspots.
7. Export both the probability map and detected hotspots as outputs.

**Dataset Details**

**1. Damodar River Shapefile**

* Source: Uploaded as an asset to GEE ("projects/ed-sayandasgupta97/assets/mrb\_rivnets\_Q09\_10").

**2. Landsat 8 Collection 2 (Level 2)**

* Collection ID: LANDSAT/LC08/C02/T1\_L2
* Resolution: 30m per pixel
* Spectral Bands Used:
  + **SR\_B2** (Blue)
  + **SR\_B3** (Green)
  + **SR\_B4** (Red)
  + **SR\_B5** (NIR)
  + **SR\_B6** (SWIR 1)
  + **SR\_B7** (SWIR 2)
  + **ST\_B10** (Thermal)

**Step-by-Step Process**

**Step 1: Load Data and Generate Buffer Zone**

* The **Damodar River** shapefile is loaded and buffered by **1 km** to create a zone of interest.

var damodarRiver = ee.FeatureCollection("projects/ed-sayandasgupta97/assets/mrb\_rivnets\_Q09\_10");

var riverBuffer = damodarRiver.geometry().buffer(1000);

**Step 2: Load and Preprocess Landsat Imagery**

* Filters Landsat 8 imagery for the year **2023** within the buffer area.
* Applies scaling factors to convert digital numbers (DN) to surface reflectance values.

var landsat = ee.ImageCollection('LANDSAT/LC08/C02/T1\_L2')

.filterDate('2023-01-01', '2023-12-31')

.filterBounds(riverBuffer)

.map(function(image) {

var opticalBands = image.select(['SR\_B2', 'SR\_B3', 'SR\_B4', 'SR\_B5', 'SR\_B6', 'SR\_B7'])

.multiply(0.0000275).add(-0.2);

return opticalBands.copyProperties(image, ['system:time\_start']);

});

**Step 3: Compute Spectral Indices**

* **NDWI** highlights water bodies.
* **NDVI** identifies vegetation.
* **MNDWI** is a refined version of NDWI for improved water detection.
* **BSI** reveals bare soil exposure, crucial for sand mining detection.

var ndwi = composite.normalizedDifference(['SR\_B3', 'SR\_B5']).rename('NDWI');

var ndvi = composite.normalizedDifference(['SR\_B5', 'SR\_B4']).rename('NDVI');

var mndwi = composite.normalizedDifference(['SR\_B3', 'SR\_B6']).rename('MNDWI');

**Step 4: Create Probability Model for Sand Mining**

The model assigns weights to different indices based on their correlation with sand mining activity:

* **High BSI** and **low NDVI** increase the probability.
* **Moderate MNDWI** values are also associated with sand mining.

var sandminingProbability = ee.Image(1)

.where(bsi.gt(0.1), 2)

.where(ndvi.lt(0.2), 3)

.where(mndwi.gt(-0.3).and(mndwi.lt(0.3)), 2)

.where(bsi.gt(0.2).and(ndvi.lt(0.1)), 4)

.divide(4);

**Step 5: Temporal Analysis (Change Detection)**

* Historical Landsat imagery for **2018** is compared to detect changes in **BSI** over time.
* Areas with a significant increase in BSI are flagged.

var bsiChange = bsi.subtract(historicalBSI).rename('BSI\_change');

var changeMask = bsiChange.gt(0.1);

**Step 6: Identify Hotspots**

* Areas with a **sand mining probability > 0.7** are identified as hotspots.

var hotspots = finalProbability.gt(0.7);

**Step 7: Visualization**

* The following visualization layers are added:
  + **Damodar River (Blue)**
  + **Buffer Zone (Red, 30% opacity)**
  + **Landsat False Color Composite**
  + **Sand Mining Probability Map (Color Gradient: Green to Red)**
  + **Hotspots (Red)**

**Step 8: Export Results**

* **Probability Map** exported as GeoTIFF
* **Hotspots** exported as Shapefiles

Export.image.toDrive({

image: finalProbability,

description: 'Damodar\_Sandmining\_Probability',

scale: 30,

region: riverBuffer,

maxPixels: 1e9

});

**Output Interpretation**

* **Probability Map:** Shows varying likelihood of sand mining activity:
  + **Green:** Low probability
  + **Yellow:** Medium probability
  + **Orange:** High probability
  + **Red:** Very high probability
* **Hotspots Map:** Red-marked areas identify likely sand mining zones that require closer inspection.

**Future Improvements**

* Implement machine learning models (e.g., Random Forest or SVM) for better accuracy.
* Incorporate additional datasets such as DEM (Digital Elevation Models) or hydrological data.
* Introduce temporal filtering to track seasonal changes more effectively.

**References**

* Landsat 8 Collection 2 Documentation
* Google Earth Engine Documentation

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For questions or feedback, please contact [your email or GitHub profile link].