Lab 3: Mapping Environmental Risk of Malaria in Uganda using Google Earth Engine (GEE)

Objective:
Participants will use Google Earth Engine to analyze vegetation (NDVI) and rainfall (CHIRPS) data across Uganda to identify environmental conditions that may support malaria transmission.

Materials Needed:

- A Google Earth Engine account: https://earthengine.google.com/
- Internet access and modern web browser
- Sample GEE script (included below)
- Optional: Uganda district boundary shapefile for advanced analysis

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Step-by-Step Instructions:

1. Access Google Earth Engine

- Go to https://code.earthengine.google.com/
- Sign in with your Google account (must be registered with GEE)

2. Create a New Script

- Click the "**New**" button and name your script (e.g., `Malaria_Environment_Uganda`)

3. Load and Process NDVI Data

```
// Define area of interest (optional, here it's Uganda)
var uganda = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017")
  .filter(ee.Filter.eq('country_na', 'Uganda'));

// Load MODIS NDVI Image Collection for 2022
var ndvi = ee.ImageCollection('MODIS/006/MOD13Q1')
  .filterDate('2022-01-01', '2022-12-31')
  .filterBounds(uganda) // Optional but preferred for performance
  .select('NDVI')
  .median() // More robust than mean for NDVI
  .clip(uganda); // Optional: clip to Uganda

// Print info to console
print('NDVI Image:', ndvi);

// Visualize
var visParams = {
  min: 0,
```

```
  max: 9000,
  palette: ['white', 'green']
};
Map.centerObject(uganda, 6);
Map.addLayer(ndvi, visParams, 'Median NDVI 2022');
```

This loads MODIS NDVI data for 2022 and calculates the annual mean NDVI. NDVI is a proxy for vegetation health and can indicate suitable mosquito habitats.

4. Load and Process Rainfall Data

```
// Define Uganda boundary
var uganda = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017")
  .filter(ee.Filter.eq('country_na', 'Uganda'));

// Load CHIRPS daily precipitation for 2022
var rainfall = ee.ImageCollection('UCSB-CHG/CHIRPS/DAILY')
  .filterDate('2022-01-01', '2022-12-31')
  .filterBounds(uganda)
  .sum()
  .clip(uganda);

// Rename the band for clarity
rainfall = rainfall.rename('Annual_Rainfall_2022');

// Visualize
var rainfallVis = {
  min: 0,
  max: 2000,
  palette: ['lightblue', 'blue', 'darkblue']
};

Map.addLayer(rainfall, rainfallVis, 'Total Rainfall 2022');
Map.centerObject(uganda, 6);

// Print image for inspection
print('Total Annual Rainfall (2022):', rainfall);
```

This loads CHIRPS daily rainfall data for 2022 and sums it to produce total annual rainfall.

5. Define the Uganda Region

```
var uganda = ee.FeatureCollection('USDOS/LSIB_SIMPLE/2017')
  .filter(ee.Filter.eq('country_na', 'Uganda'));
```

This selects Uganda from a global country boundary dataset to define the area of interest.

6. Visualize the Layers

```
// NDVI Visualization
Map.addLayer(ndvi.clip(uganda), {
  min: 0,
  max: 9000,
```

```
  palette: ['white', 'lightgreen', 'darkgreen'],
  opacity: 1
}, 'Vegetation Density (NDVI) 2022');

// Rainfall Visualization
Map.addLayer(rainfall.clip(uganda), {
  min: 0,
  max: 2000,
  palette: ['white', 'lightblue', 'darkblue'],
  opacity: 1
}, 'Total Rainfall (mm) 2022');

// Add Uganda boundary outline last so it overlays clearly
Map.addLayer(uganda.style({color: 'red', fillColor: '00000000', width: 1}),
{}, 'Uganda Boundary');
```

This centers the map on Uganda and displays the NDVI and rainfall layers.

7. Export the Raster Layers

```
// Export NDVI to Google Drive
Export.image.toDrive({
  image: ndvi.clip(uganda),
  description: 'Uganda_NDVI_2022',
  scale: 250,
  region: uganda.geometry(),
  maxPixels: 1e9,
  fileFormat: 'GeoTIFF',
  folder: 'GEE_Exports'
});

// Export Rainfall to Google Drive
Export.image.toDrive({
  image: rainfall.clip(uganda),
  description: 'Uganda_Rainfall_2022',
  scale: 5000,
  region: uganda.geometry(),
  maxPixels: 1e9,
  fileFormat: 'GeoTIFF',
  folder: 'GEE_Exports'
});
```

These exports save the NDVI and rainfall rasters as GeoTIFFs to your Google Drive for further use in QGIS.

8. Visualize in QGIS

- Download the exported GeoTIFFs from Google Drive.
- Open QGIS and load them using **Layer > Add Layer > Add Raster Layer**.
- Style the NDVI with a green color ramp and the rainfall with a blue ramp.
- Adjust min/max values and use the Histogram tool to enhance contrast.
- Add map elements (title, legend, scale bar) and export the layout.

Outcome:
Participants will generate NDVI and rainfall maps over Uganda and gain insights into environmental conditions that may influence malaria transmission risk.

Optional Extensions:

- Compare NDVI/rainfall across multiple years or seasons.
- Use the Chart tools to analyze temporal trends.
- Clip rasters by district boundaries to produce zonal statistics.
- Combine NDVI and rainfall into a simple malaria risk index.
- Overlay malaria case data if available.

Tip: You can use ChatGPT to help write or troubleshoot GEE code by describing your goals in plain language.