Task 1: Import Required Libraries

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import sklearn
import geopandas as gpd
import folium
```

Task 2: Load Natural Earth Dataset

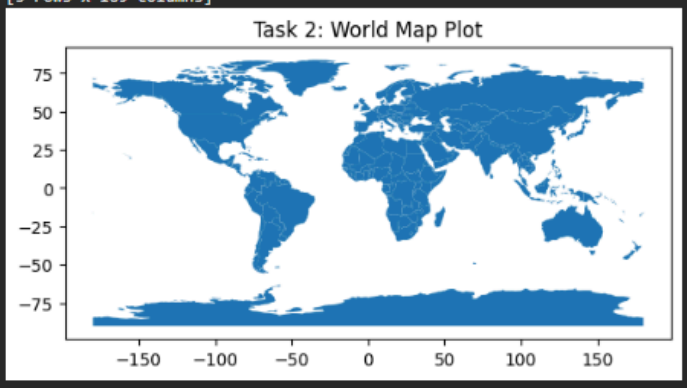
1. How many columns does the dataset contain? After running len(world.columns) in my notebook, I found that the dataset contains 169 columns.

2. What type of geometries are included? The dataset primarily includes Polygons and MultiPolygons, which map out the 2D shapes and borders of the countries.

3. What does the geometry column represent? The geometry column holds the actual spatial data, the collections of coordinate points that define the physical shape, boundaries, and exact location of each country on the map.

```
--- Task 2 Outputs ---
       featurecla  scalerank  LABELRANK                SOVEREIGNT SOV_A3  \
0  Admin-0 country          1          6                      Fiji    FJI
1  Admin-0 country          1          3  United Republic of Tanzania    TZA
2  Admin-0 country          1          7            Western Sahara    SAH
3  Admin-0 country          1          2                    Canada    CAN
4  Admin-0 country          1          2  United States of America    US1

   ADM0_DIF  LEVEL             TYPE TLC                      ADMIN  ...  \
0         0      2  Sovereign country   1                      Fiji  ...
1         0      2  Sovereign country   1  United Republic of Tanzania  ...
2         0      2      Indeterminate   1            Western Sahara  ...
3         0      2  Sovereign country   1                    Canada  ...
4         1      2            Country   1  United States of America  ...

      FCLASS_TR     FCLASS_ID     FCLASS_PL FCLASS_GR  FCLASS_IT  \
0          None          None          None      None       None
1          None          None          None      None       None
2  Unrecognized  Unrecognized  Unrecognized      None       None
3          None          None          None      None       None
4          None          None          None      None       None

      FCLASS_NL FCLASS_SE  FCLASS_BD FCLASS_UA  \
0          None      None       None      None
1          None      None       None      None
2  Unrecognized      None       None      None
3          None      None       None      None
4          None      None       None      None
```

```
                                                geometry
0  MULTIPOLYGON (((180 -16.06713, 180 -16.55522, ...
1  POLYGON ((33.90371 -0.95, 34.07262 -1.05982, 3...
2  POLYGON ((-8.66559 27.65643, -8.66512 27.58948...
3  MULTIPOLYGON (((-122.84 49, -122.97421 49.0025...
4  MULTIPOLYGON (((-122.84 49, -120 49, -117.0312...

[5 rows x 169 columns]
```



Task 4: Convert to Metric CRS for Area Calculation

1. Why can't we compute the area accurately using EPSG:4326? Since EPSG:4326 uses degrees, and the actual physical distance of a "degree" shrinks as you move from the equator toward the poles, trying to calculate an area directly from degrees gives highly inaccurate and distorted results.

2. What unit is EPSG:3857 based on? EPSG:3857 (the Web Mercator projection) is a Projected Coordinate Reference System based on meters, which is why we switched to it for our area calculations.

```
--- Task 4 Outputs ---
                       ADMIN       area_m2
0                       Fiji  2.128334e+10
1  United Republic of Tanzania  9.522552e+11
2               Western Sahara  1.171023e+11
3                     Canada  5.216648e+13
4     United States of America  2.186228e+13

Area Reprojection ✅ Complete
```

Task 5: Extract Centroid Coordinates

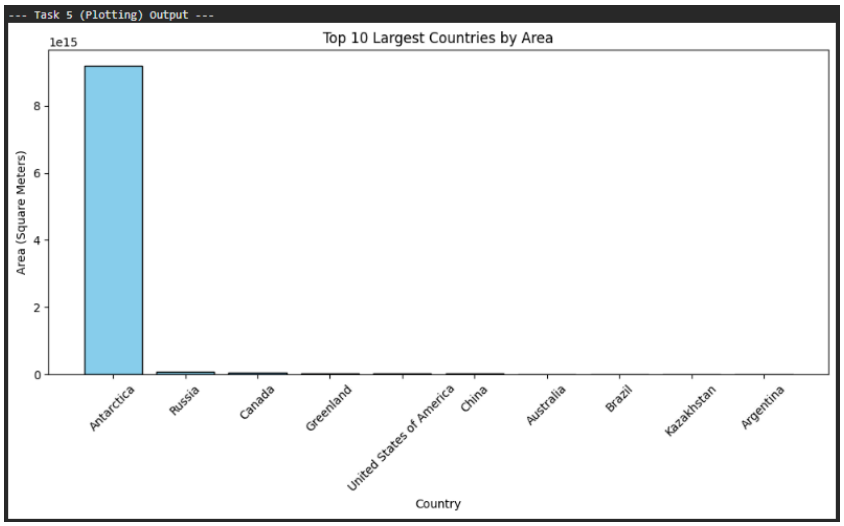
1. What is a centroid? A centroid is the exact geometric center point, or the "center of mass," of a spatial feature like a country's polygon in our dataset.

2. How can centroid coordinates be used in clustering? Since machine learning algorithms need standard numerical data to calculate distances between points, reducing a complex country shape down to a single (X, Y) coordinate allows algorithms like K-Means to easily group countries based on their spatial proximity.

3. Why do we extract X and Y separately? Standard machine learning libraries like scikit-learn can't process complex Point geometry objects natively. I had to extract the X (longitude) and Y (latitude) into separate columns so the model could treat them as standard, independent numerical features.

```
--- Task 5 Outputs ---
                       ADMIN             x             y
0                       Fiji  1.824878e+07 -1.958098e+06
1  United Republic of Tanzania  3.869296e+06 -7.003071e+05
2               Western Sahara -1.348403e+06  2.794163e+06
3                     Canada -1.079779e+07  1.044422e+07
4     United States of America -1.329713e+07  6.667416e+06
```

Task 5 (Part 2): Plot the top 10 largest countries by area



Reflection:
One difficulty I encountered was initially around Coordinate Reference Systems, specifically understanding why area calculations fail so drastically when using standard degree-based coordinates like EPSG:4326. Through this lab, I learned that properly reprojecting spatial data into a metric system is an absolute requirement before any true geographic analysis or machine learning can happen. This hands-on experience with GeoPandas made me realize just how important accurate spatial data preprocessing will be for mapping vulnerable zones accurately in my hyper-local flood forecasting system for Santa Cruz. Ultimately, I now see that without the correct foundational geometries and metric projections, any predictive model relying on that geographic data will be fundamentally flawed