Leveraging Geospatial Technologies to Identify Optimal Locations for Solar Photovoltaic Farms.

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EIS

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International Federation of Surveyors
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Contents

Introduction

- Energy is a fundamental requirement for steering global development

(Gielen et al., 2019).

- fossil fuel emission by **1.1%** in 2023 compared to 2022 levels, totaling **36.8** billion metric tons of carbon dioxide emissions in 2023, according to a NASA study

(Roca-Fernandez et al., 2025).

- The need for a renewable, clean and affordable energy alternative

(IRENA, 2022).

- An Act of parliament (Renewable Energy Act, 2011) Act (834) as a legal framework to guide renewable energy adoption in Ghana

(Suleman & Sowah, 2024).

Research Aim and Objectives

- The study aim to identify precise locations for Solar PV installation in Central Region using geospatial technologies and multi-criteria decision making.
- The specific objective are;

    1. To utilize **GIS**, remote sensing and **GNSS** to determine suitable sites for large-scale solar PV farms in the study area.

    2. To assess the influence of environmental, climatic and topographic factors on PV site selection.

    3. To validate findings using ground-truth data.

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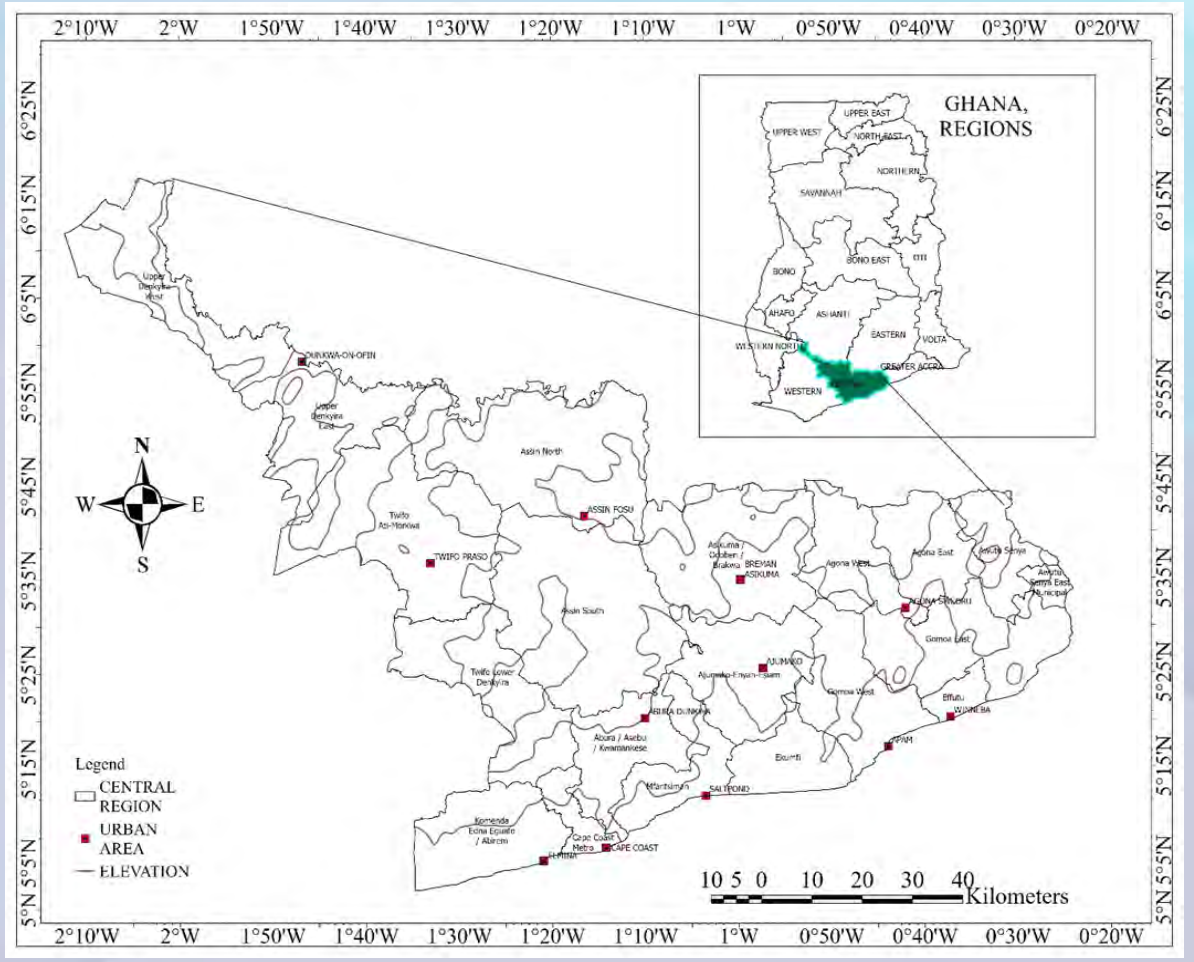
Study Area

- Lies between latitude 5°29'55.99''N and longitude -1°00'0.00''W (Pavelic et al., 2012).
- Land area of approximately 9,826 Km^2.
- Population of 2,859,821 (2021) census
- (M.W. Agyekum et al., 2024).
- Global Horizontal Irradiance (GHI) of 1728.4 kWh/m^2 (Solargis, 2024).



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Methodology: Materials

Data	Source	Spatial Resolution	Date Acquired
Sentinel-2B/ L2A	Copernicus Data Ecosystem (CDE)	10 m	1/07/2014
Copernicus DEM	Open topography	30 m	1/07/2024
Ghana Shapefile	Lands Commission Ghana **(SMD)**	N/A	20/06/2024
Software	Purpose		
ArcGIS Pro 3.0	Data analysis and cartography		
Google Earth Pro	Solar PV suitable site ground-truthing		
QGIS (Qfield) and Open Street Map **(OSM)**	Data collection form design and ground-truth overlay		
Draw.io	Flow Chart design		
Microsoft Office Suite	Graphs and documentation		

Table 1: Study Materials and Software

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Weight Assignment – Modified AHP

- Solar radiation: 35% (Most Significant)
- Slope: 18%
- Aspect: 14%
- LULC: 12%
- Urban proximity: 7%
- Road proximity: 8%
- Gridline proximity: 5%
- Protected area proximity: 1%

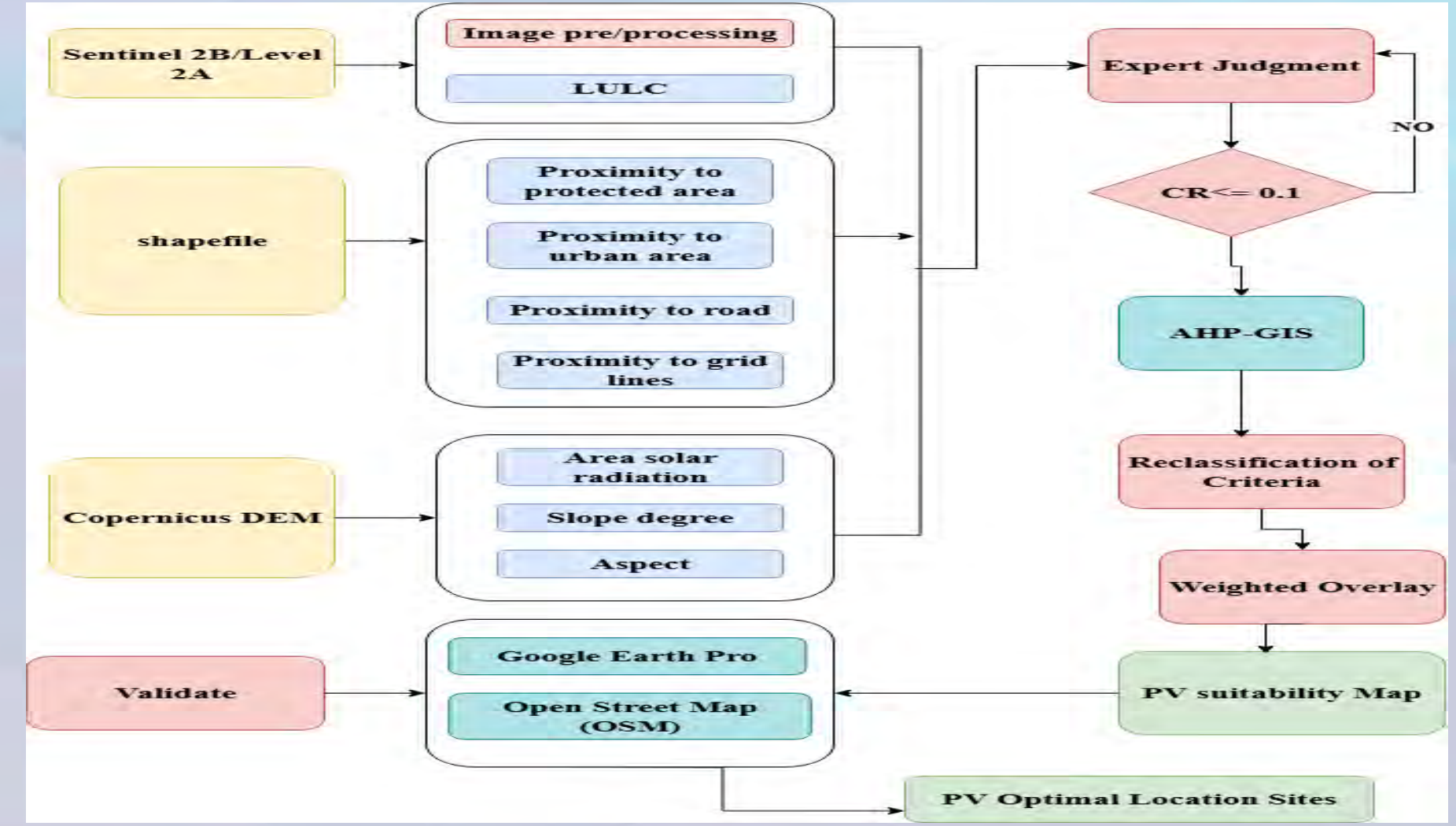
(Less significant)

- CR value: 0.08 (Accepted as CR < 0.1
- There was consistency between literature review and expert consultations.
- The assigned weight are valid for solar PV site suitability selection
- $CR = \frac{CI}{RI}$, where **CI** = Consistency index, **RI** = Random.

$CI = \frac{\lambda max - n}{n-1}$, where:

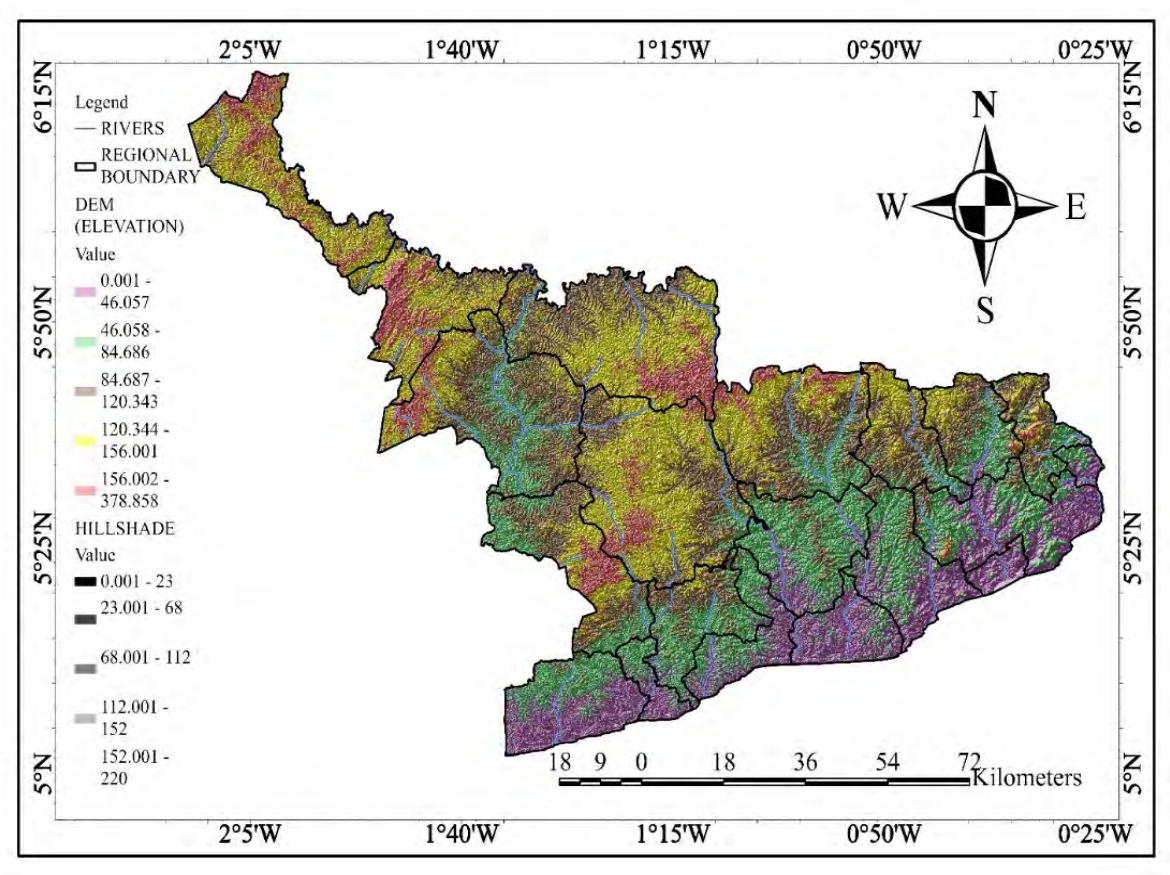
λ_{max} is the maximum eigenvalue of the comparison matrix, n is the number of criteria.

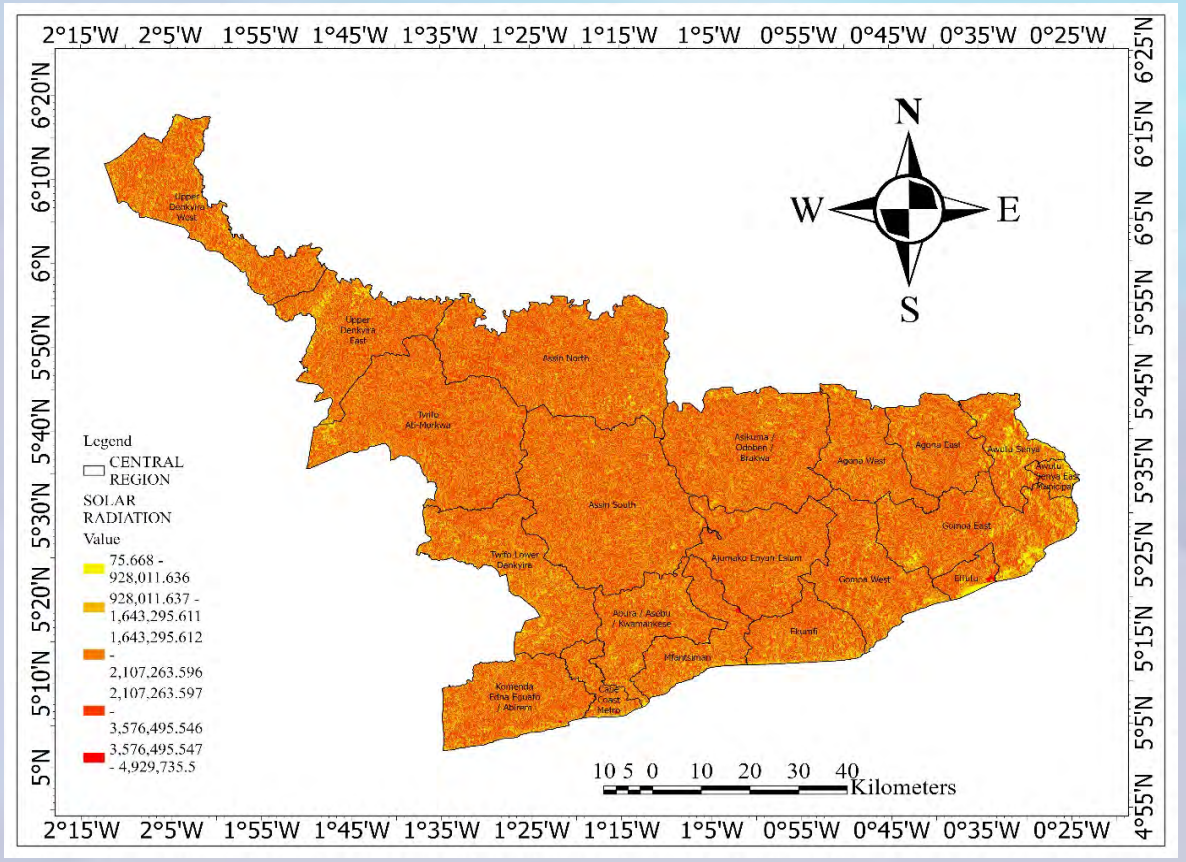
Flow Chart


Sentinel 2B/Level 2A
Image pre/processing
LULC
shapefile
Proximity to protected area
Proximity to urban area
Proximity to road
Proximity to grid lines
Copernicus DEM
Area solar radiation
Slope degree
Aspect
Validate
Google Earth Pro
Open Street Map (OSM)
Expert Judgment
NO
CR<= 0.1
AHP-GIS
Reclassification of Criteria
Weighted Overlay
PV suitability Map
PV Optimal Location Sites

Results:

Objective 1





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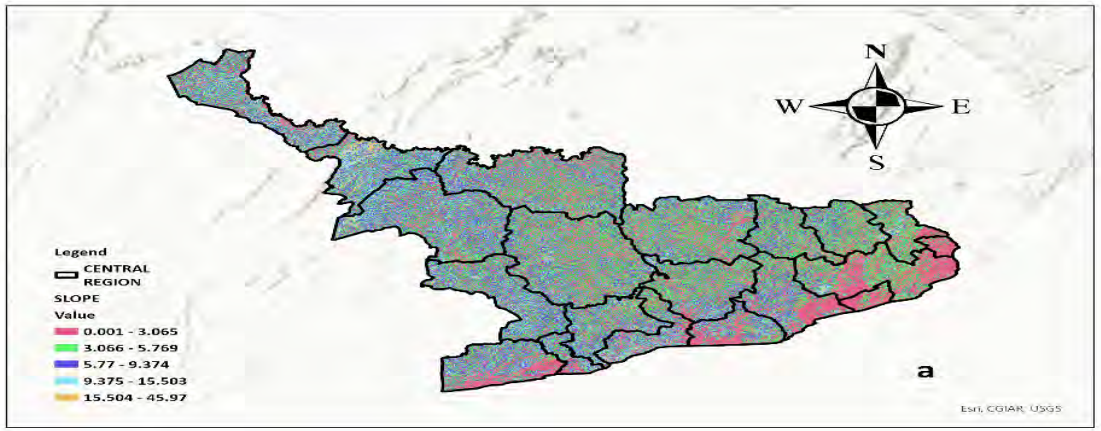
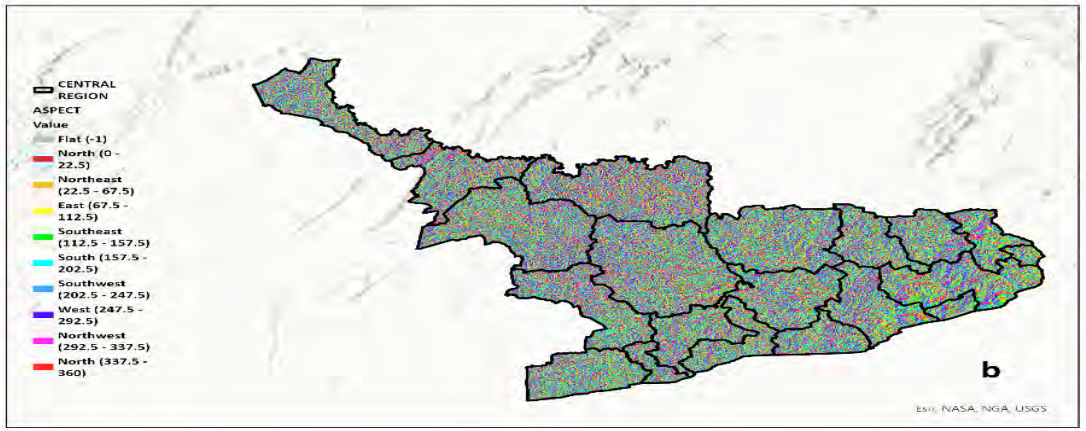
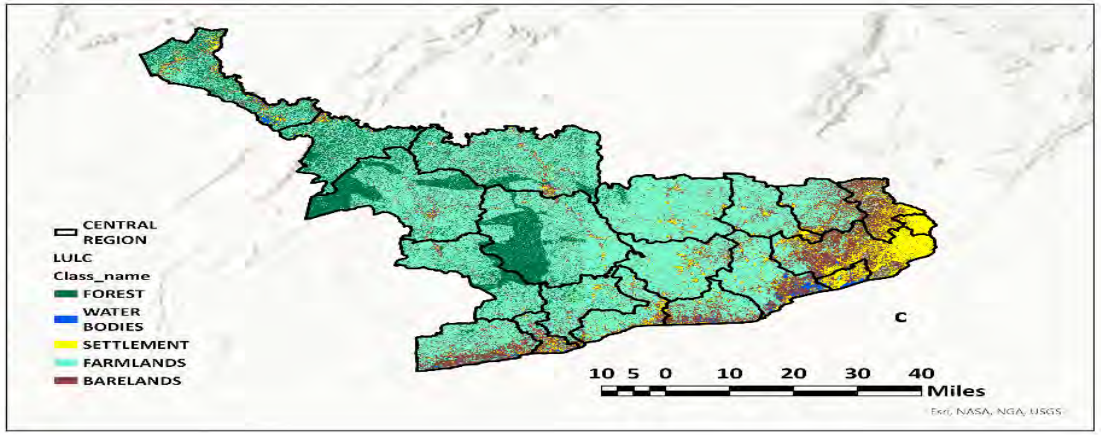
Objective 1







LULC: 2024 (SMV)

- Overall Accuracy: 95.6%
- Cohen's Kappa: 0.93

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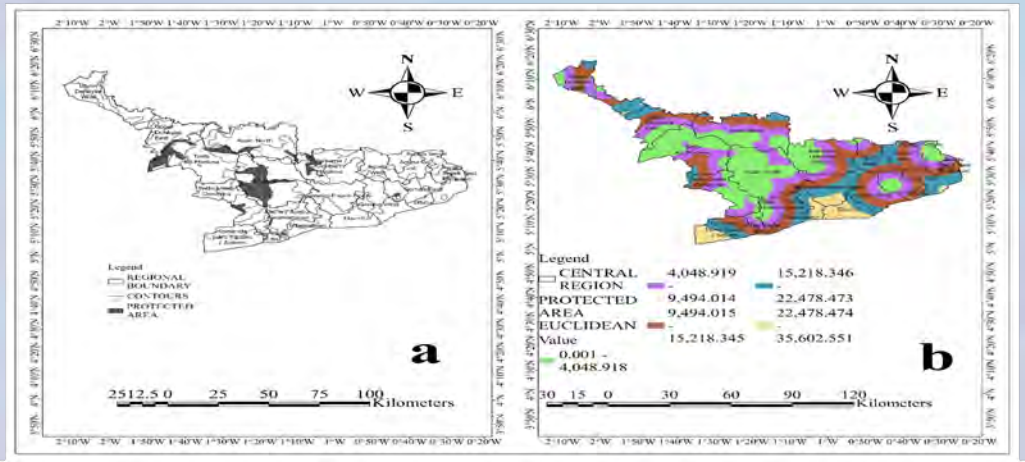
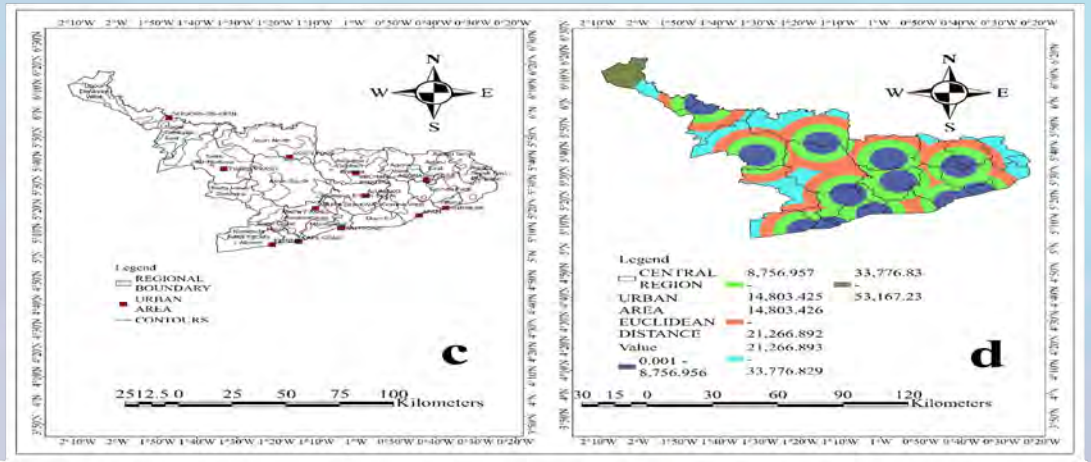
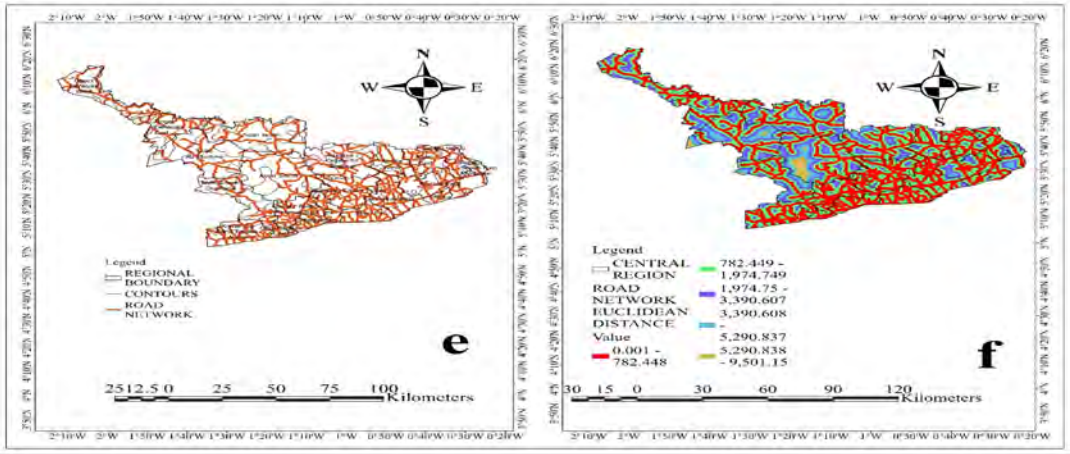
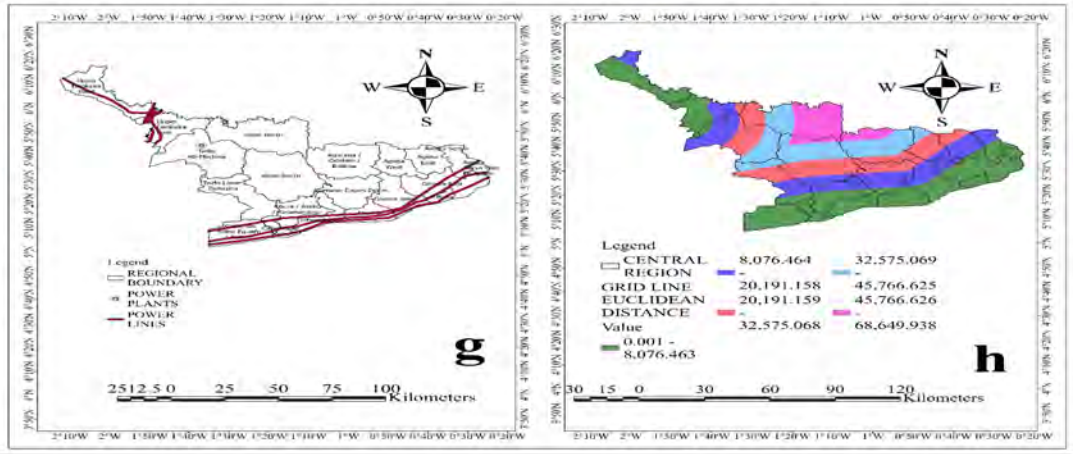
Objective 1









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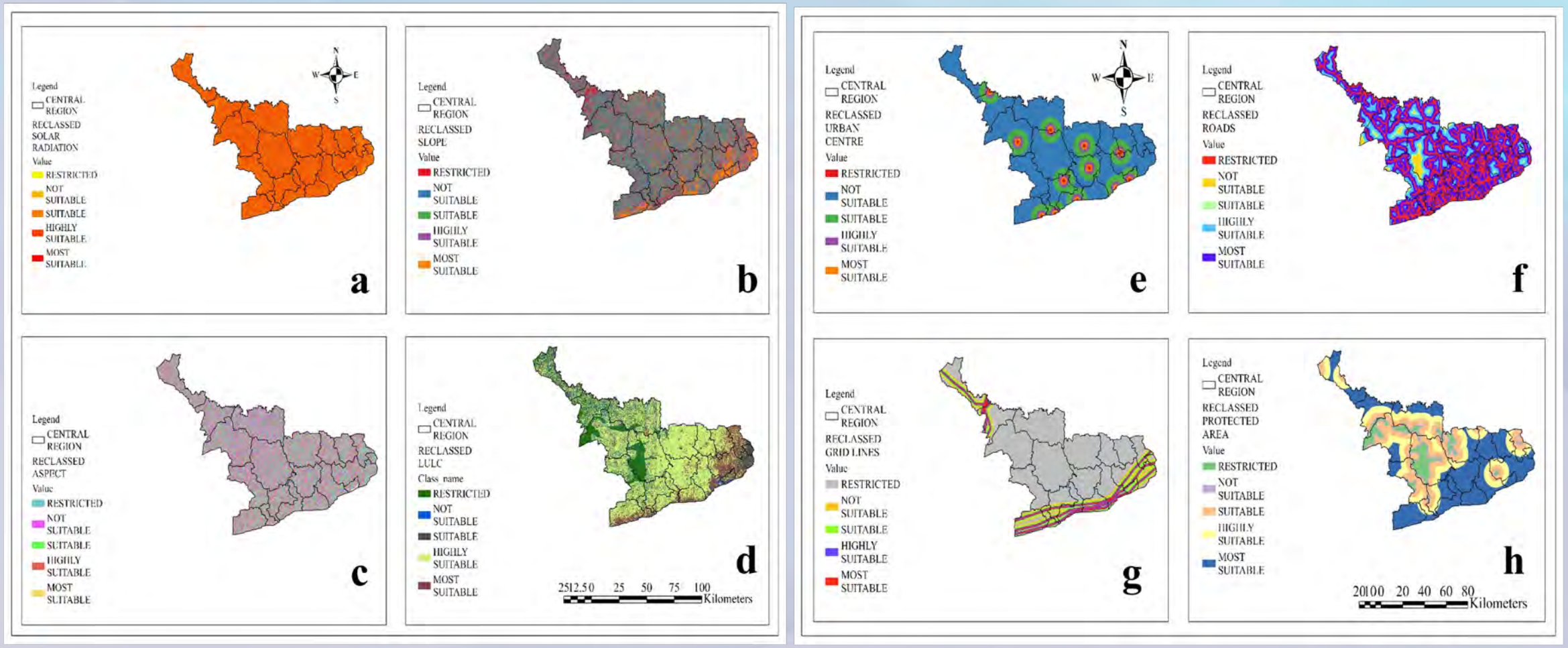
Objective 2: Criteria Reclassification



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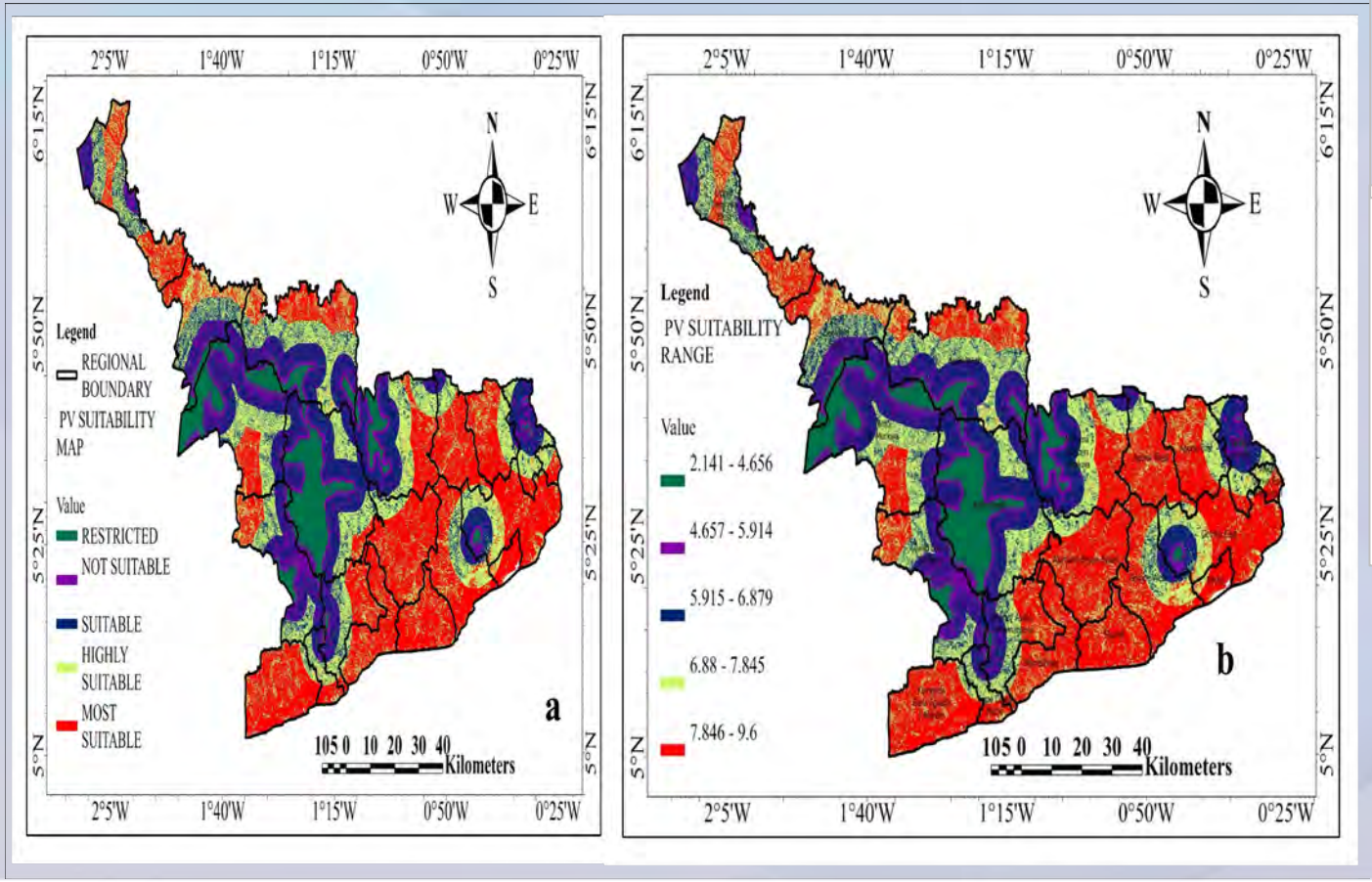
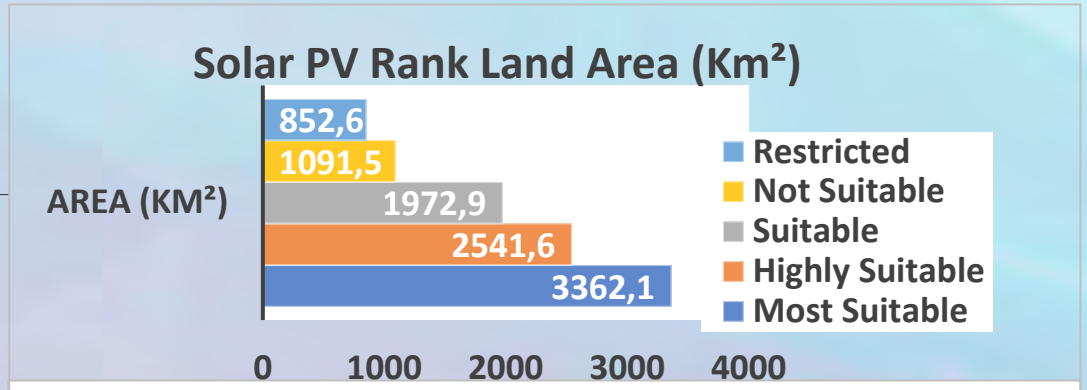
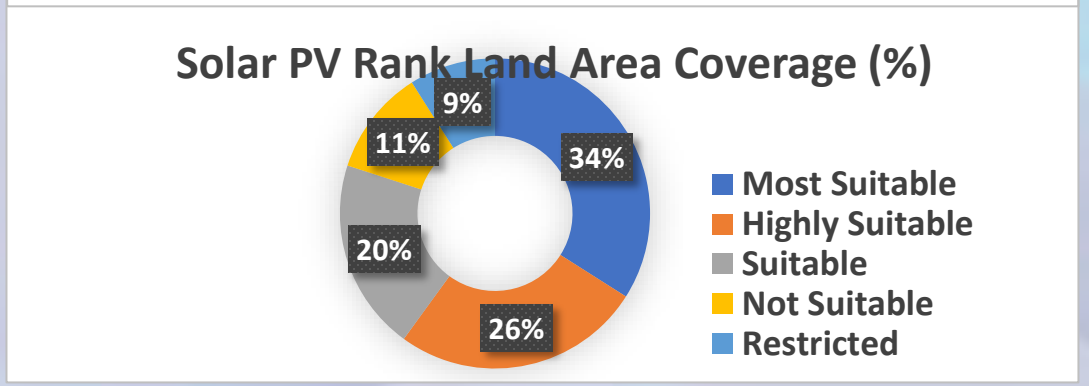
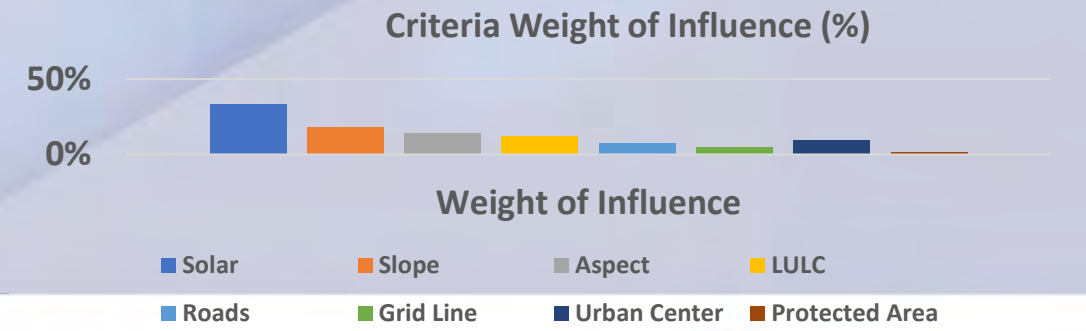
Objective 2: Solar PV Suitability Map









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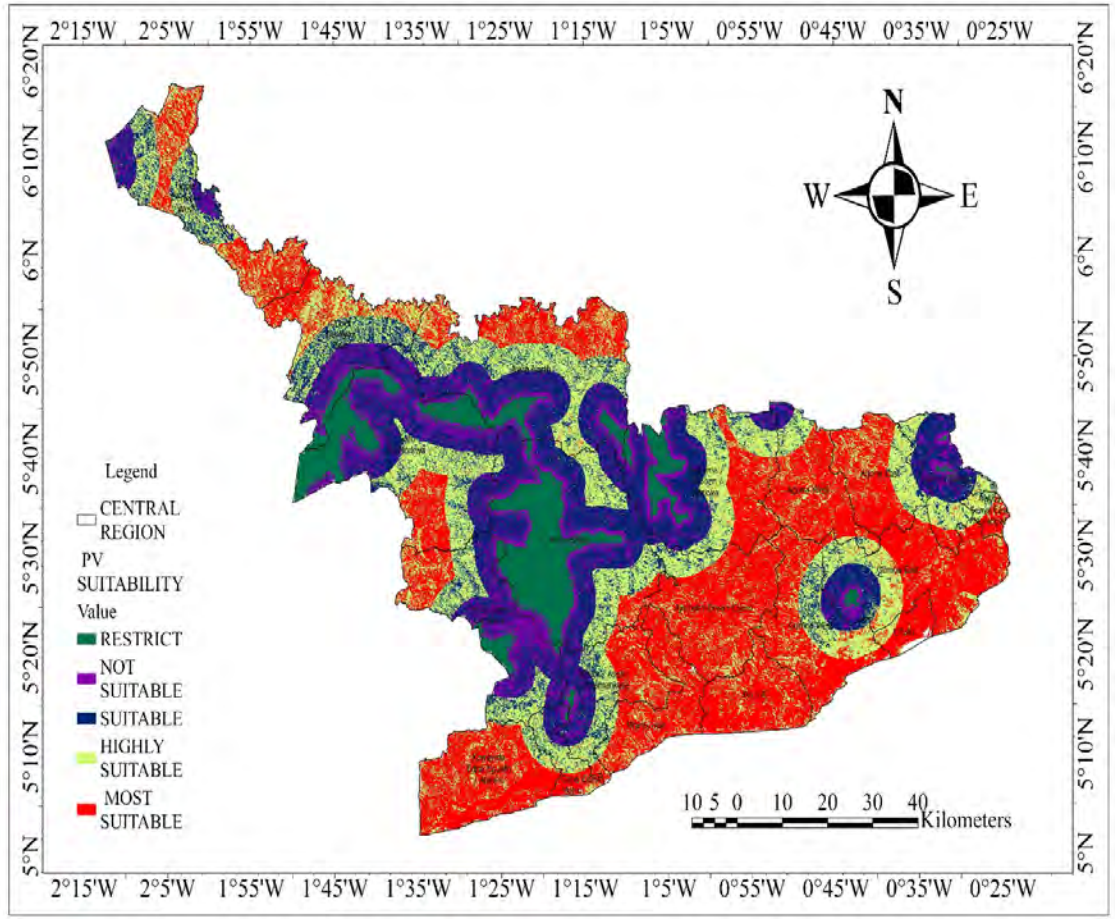
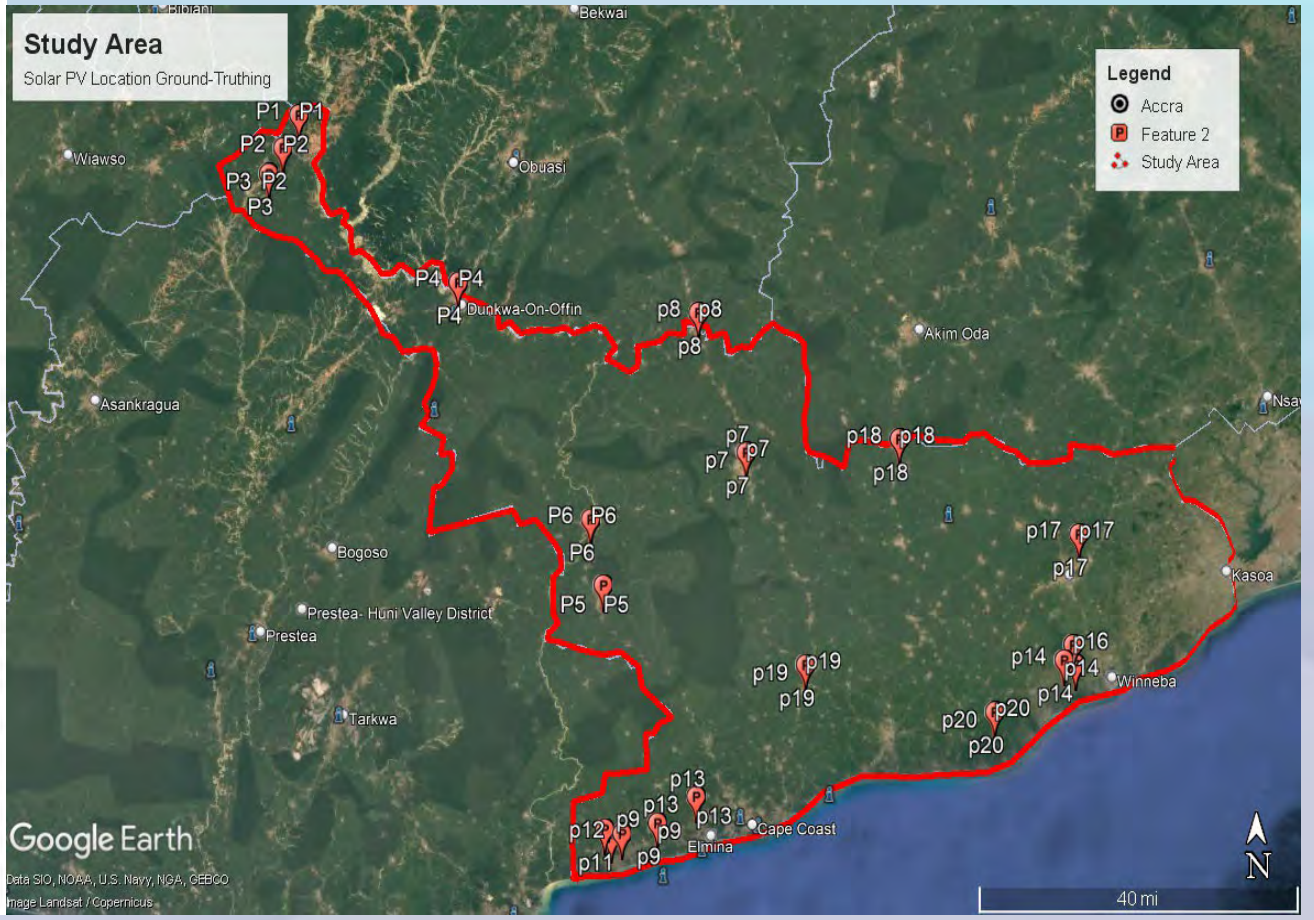
Objective 3





PV Suitability Ground-truth.

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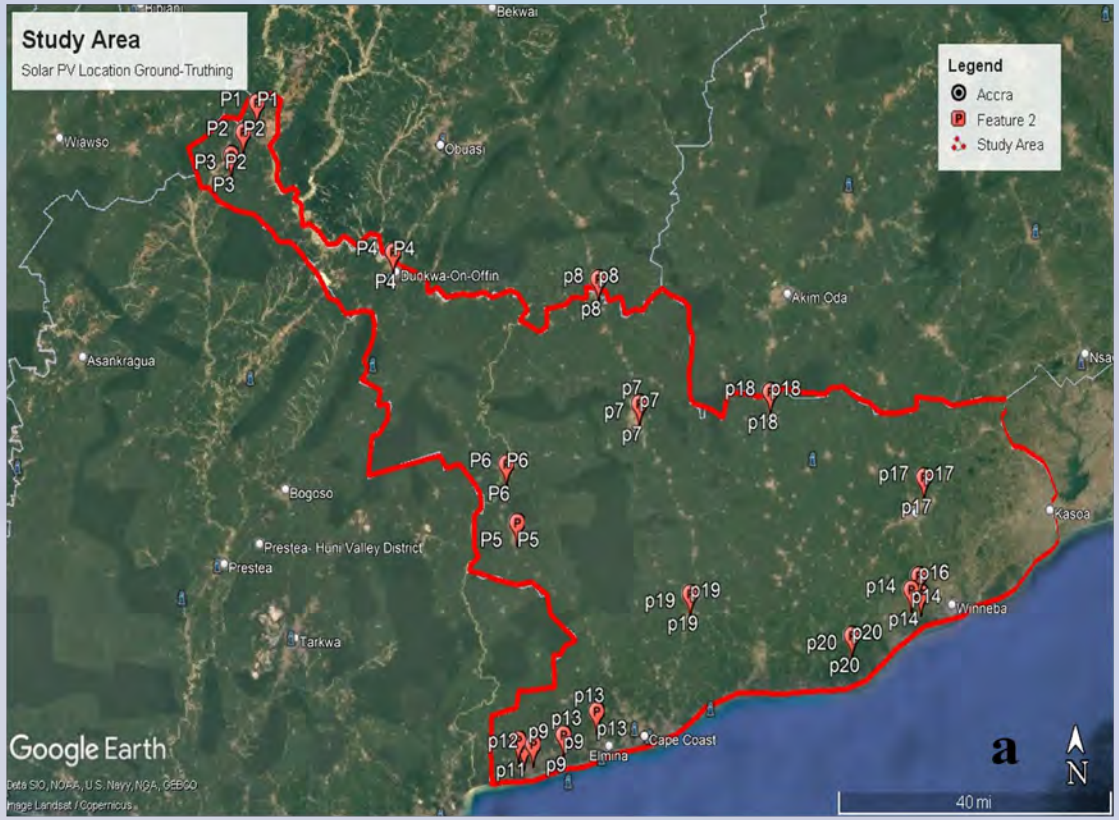
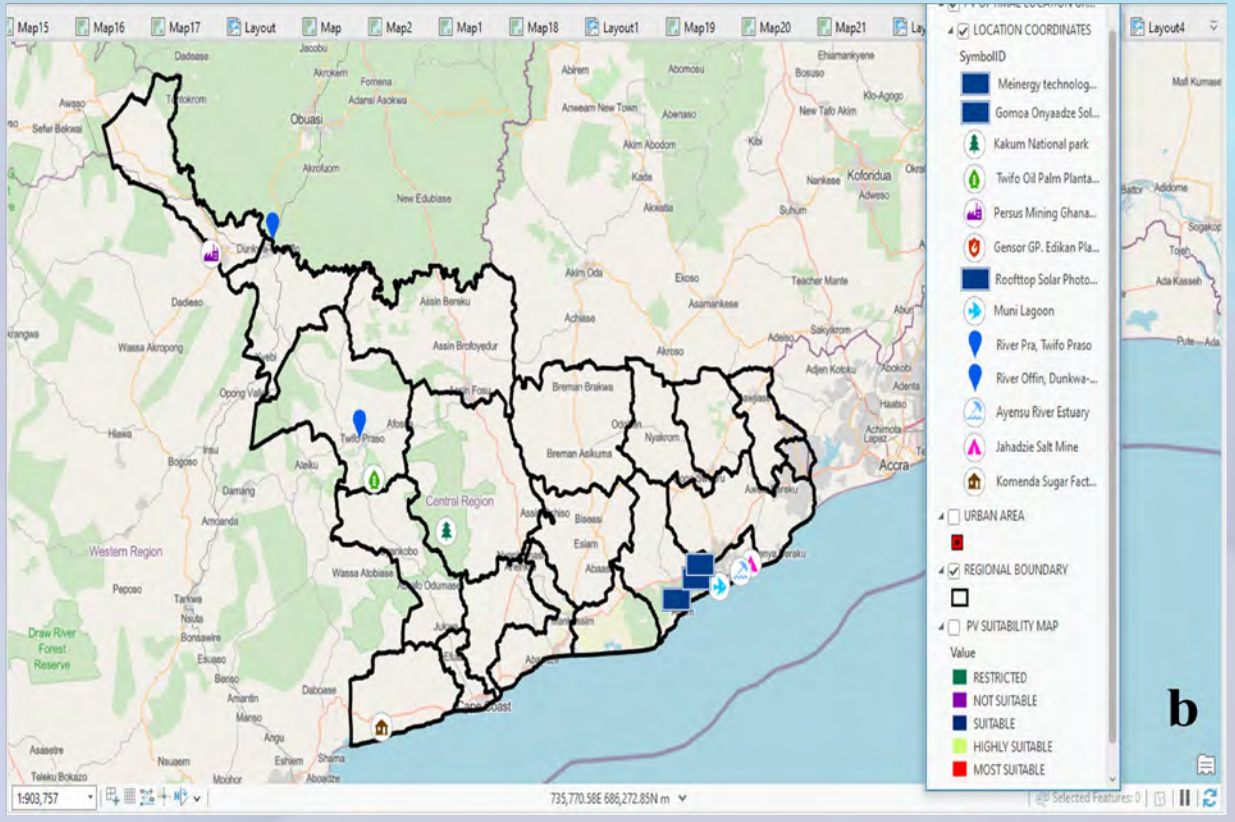
Objective 3





Validating Ground-truth data with **OSM**

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Ground-truth Locations and POIs

Location (Ground Truth PV Facilities and POIs)	Latitude (N)	Longitude (E)
Meinergy Technology Limited Solar Plant	5°22'18.65''N	0°41'35.62''W
Gomoa Onyaadze Solar Power Station	5°22'40.00''N	0°42'13.10''W
Rooftop Photovoltaic, Apam	5°18'21.68''N	0°45'14.72''W
Kakum National Park	5°26'32.25''N	1°20'13.60''W
EdikanMine, Persus Mining Ghana Limited	5°57'24.29''N	1°55'56.22''W
Gensor GP Edikan Power Plant (Ayamfuri).	5°57'29.45''N	1°55'53.44''W
Twifo Oil Palm Plantation	5°32'18.45''N	1°31'15.65''W
River Pra, Twifo Praso	5°36'38.49''N	1°33'24.18''W
River Offin, Dunkwa-on-Offin	5°58'55.86''N	1°46'33.67''W
Muni Lagoon	5°19'45.92''N	0°38'43.55''W
Ayensu River Estuary	5°21'24.13''N	0°35'29.99''W
Jahazdie Salt Mine	5°22'6.25''N	0°35'55.95''W
Komenda Sugar Factory	5°4'1.37''N	1°30'6.87''W

Conclusion

- Geospatial technologies including GIS, remote sensing and GNSS provides intelligent and data-driven approach to solar PV site selection.
- Integrating different environmental, climatic and topographic parameters ensure site selection optimization.
- Geospatial approach to PV site selection prevents energy facility-land use conflict and promote effective energy spatial planning.

Recommendation

- Further study must employ geospatial automation workflow to execute the study's task.
- Further study could focus on community level (Energy communities) application with laser scanning technology; the driver of digital twins.
- Government should adopt GIS-base framework in renewable energy policy planning.
- Encourage collaboration between government, academia, and investors to accelerate solar PV adoption using spatial data.

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