Analysis and Prediction of the Land Use and Land Cover in Zamboanga using QGIS

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Abstract. The Zamboanga Peninsula, located in the southwestern region of the Philippines, plays a significant role in the country's socio-economic landscape due to its strategic geographic position and rich natural resources. Comprising Zamboanga del Norte, Zamboanga del Sur, Zamboanga Sibugay, and Zamboanga City, the peninsula is a vital center for agriculture, fisheries, and trade. However, rapid urbanization and industrial development have resulted in changes to land use, leading to concerns about environmental sustainability and disaster risk management. To understand the extent of these changes, an analysis of satellite imagery and land cover data is essential. Through the application of tools like QGIS and remote sensing techniques, this study aims to map and analyze land use transformations in the Zamboanga Peninsula over time. The findings suggest a trend of increasing urban sprawl, deforestation, and the loss of agricultural lands, with implications for local ecosystems and communities. The study emphasizes the need for sustainable land management practices that balance development and environmental preservation, ensuring the continued well-being of the region's population while safeguarding its natural resources.

Keywords: Zamboanga Peninsula, Land Use, Urbanization, Environmental Sustainability, Remote Sensing.

1 Introduction

The Zamboanga Peninsula, located in the southwestern part of the Philippines, comprises the provinces of Zamboanga del Norte, Zamboanga del Sur, Zamboanga Sibugay, and the highly urbanized Zamboanga City. As of 2021, the region's population was approximately 3.88 million, with Zamboanga City serving as a significant hub for trade, agriculture, and fisheries.

The region's economy is primarily rooted in agriculture, with farming and fishing as the main economic activities for many families. In 2023, the economy of Zamboanga Peninsula grew by 4.6%, with the services sector accounting for 54.1% of the regional economy, followed by industry at 28.8%, and agriculture, forestry, and fishing at 17.1%. Notably, Zamboanga Sibugay registered the fastest growth among the region's economies.

Rapid urbanization and industrial expansion have led to significant land use changes in the region. For instance, from 2002 to 2023, Zamboanga City lost 748 hectares of humid primary forest, accounting for 6.8% of its total tree cover loss during the same period. Such deforestation contributes to environmental challenges, including habitat destruction and increased vulnerability to natural disasters. The region's susceptibility to natural disasters, such as typhoons and flooding, is exacerbated by these environmental changes.

This study aims to analyze land use and land cover (LULC) changes in the Zamboanga Peninsula, focusing on vegetation loss and urban expansion. By utilizing tools like QGIS, we seek to model future land use scenarios and provide actionable insights for sustainable development. The findings will help guide decision-makers in balancing economic growth with ecological preservation and community resilience.

2 Methodology

2.1 Study Area Selection

The Zamboanga Peninsula, in western Mindanao, Philippines, is selected for its diverse land use patterns, including urban development, agriculture, and natural ecosystems. The region faces significant land cover changes such as deforestation for agriculture, rapid urbanization in Zamboanga City, and threats to coastal ecosystems like mangroves due to land reclamation. These dynamics make it ideal for studying land use trends and predicting future changes.

2.2 Data Collection

Landsat 8 data will be used for its high-resolution multispectral imagery, ideal for analyzing land use and land cover (LULC) changes. The data for the years 2014 and 2024 will be acquired from the USGS Earth Explorer platform. These images will allow for the analysis of a 10-year span, providing insights into significant land cover transformations in the Zamboanga Peninsula.

2.3 Preprocessing

Atmospheric correction will be applied to Landsat 8 imagery using the **Semi-Automatic Classification Plugin (SCP)** in QGIS to ensure accurate spectral analysis. The process involves importing raw satellite images, applying the Dark Object Subtraction (DOS1) method to minimize atmospheric distortions like haze and scattering, and converting digital numbers (DN) to surface reflectance values. This correction enhances the reliability of the data, ensuring that land use and land cover classifications are based on accurate surface conditions.

2.4 Training and Validation Data Creation

Training and validation data will be created to ensure accurate LULC classification. Relevant land use and land cover classes (e.g., forest, soil/urban, water bodies) will be identified based on the study area's characteristics. Training polygons for each class will be digitized using QGIS, ensuring they represent diverse samples within the imagery. Validation data will be generated as independent points or polygons to evaluate the classification accuracy. These datasets are essential for training machine learning algorithms and validating results, ensuring reliable predictions and insights.

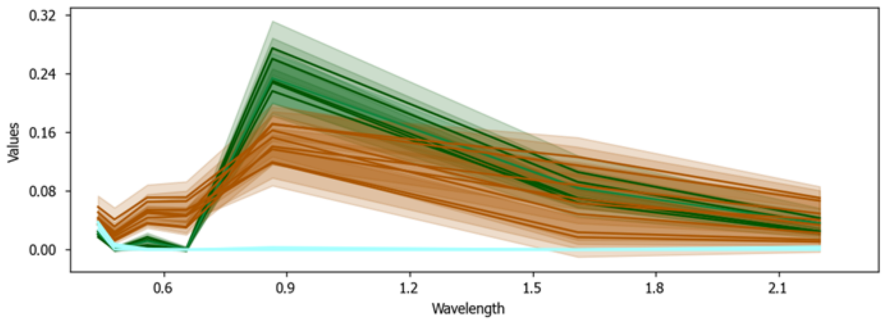

Fig. 1. Green = Forest, Brown = Soil/Urban, Blue = Water.

2.5 LULC Classification

LULC classification will be conducted using QGIS and the **Semi-Automatic Classification Plugin (SCP)**. The classification will focus on three primary land cover classes: **forest**, **soil/urban**, and **water**. Three machine learning algorithms—**Maximum Likelihood**, **Minimum Distance**, and **Spectral Angle Mapping**—will be applied to classify the imagery based on their spectral signatures.

2.6 Accuracy Assessment

The classification results will be evaluated using the validation data. Key metrics such as Overall Accuracy, Producer's Accuracy, and User's Accuracy will be calculated to assess the accuracy of the LULC classification for each algorithm.

The results from the three classification algorithms will be compared to identify the best-performing algorithm in terms of accuracy. The most accurate classification will be used for further analysis and prediction.

3 Results and Findings

Three machine learning algorithms was applied to classify the LULC data for the Zamboanga Peninsula:

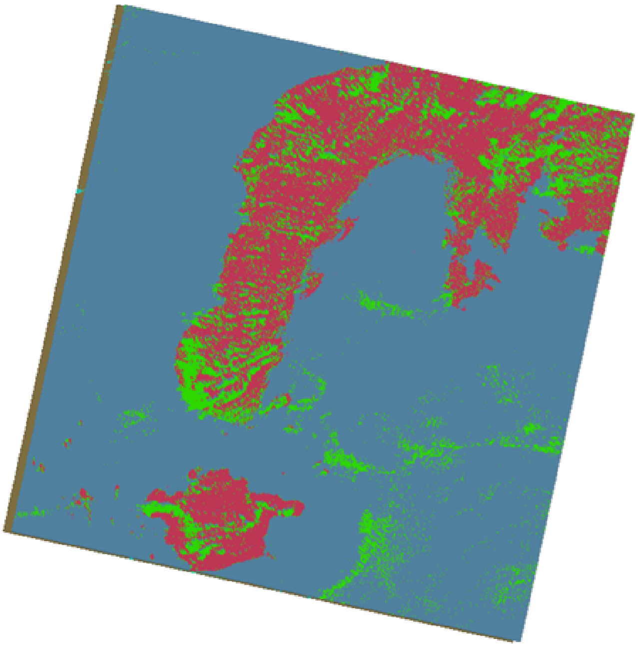

Fig. 2. Minimum Distance Algorithm

Table 1. Minimum Distance Output

%	Forest	Soil/Urban	Water
Producer's Accuracy	97.4166	96.4279	99.9477
User's Accuracy	98.4446	94.6224	99.9186

The **Minimum Distance Algorithm** achieved an overall accuracy of **99.15%** and a Kappa statistic of **0.9805**, demonstrating high classification accuracy for the Zamboanga Peninsula. The producer's accuracy was 97.42% for forest, 96.43% for soil/urban, and 99.95% for water, while the user's accuracy was 98.44% for forest and 99.92% for water. These results indicate the algorithm's strong ability to accurately classify land cover with minimal misclassification.

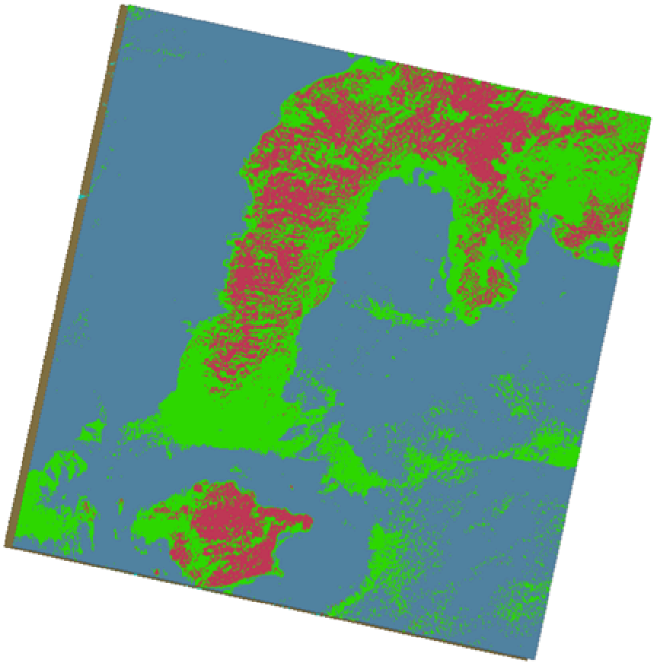

Fig. 3. Maximum Distance Algorithm

Table 2. Maximum Likelihood Output

%	Forest	Soil/Urban	Water
Producer's Accuracy	94.0334	99.9196	99.3545
User's Accuracy	99.8546	95.0854	100.0000

The **Maximum Likelihood Algorithm** classification results for the Zamboanga Peninsula, as shown in Table 2, yielded an overall accuracy of **98.74%** and a Kappa statistic of **0.9767**, indicating a strong agreement between the classified results and actual land cover. The producer's accuracy was 94.03% for forest, 99.92% for soil/urban, and 99.35% for water, while the user's accuracy was 99.85% for forest, 95.09% for soil/urban, and a perfect 100% for water. These results highlight the effectiveness of the Maximum Likelihood algorithm in accurately classifying land cover in the region with minimal misclassification, particularly for water, where the user's accuracy reached 100%.

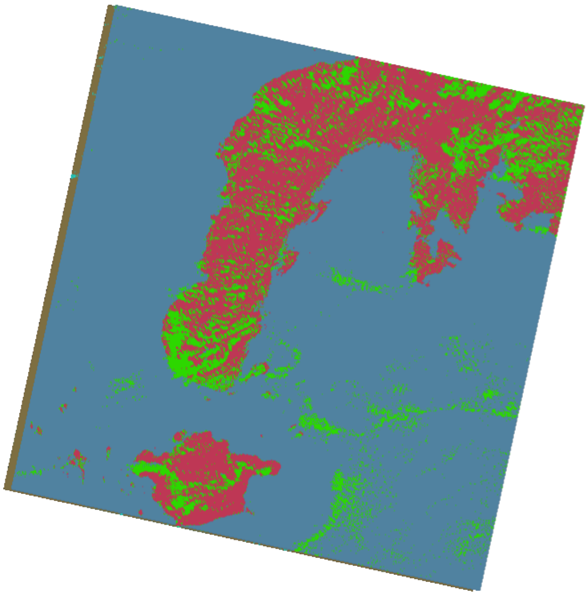

Fig. 4. Spectral Angle Mapping

Table 3. Spectral Angle Output

%	Forest	Soil/Urban	Water
Producer's Accuracy	98.5185	97.0136	99.9513
User's Accuracy	98.4557	96.8437	99.9929

The **Spectral Angle Mapping (SAM)** algorithm for land cover classification in the Zamboanga Peninsula, shown in Table 2, achieved an overall accuracy of 99.39% and a Kappa statistic of 0.9863, indicating excellent agreement between the classified results and the actual land cover. The **producer's accuracy** was 98.52% for forest, 97.01% for soil/urban, and 99.95% for water. The **user's accuracy** was 98.46% for forest, 96.84% for soil/urban, and 99.99% for water. These results reflect the high effectiveness of SAM in accurately identifying land cover types, with particularly strong performance in classifying water.

4 Prediction and Analysis

Using the best-performing classification algorithm, future LULC changes in the Zamboanga Peninsula will be predicted for the year 2034. The model will extrapolate trends based on the observed changes between 2014 and 2024.

Table 4. Cross Classification Output

Raster Value	Reference	Classification	PixelSum	Area(metre^2)
1	1	1	6237070	5613363000
2	2	1	2095708	1886137200
3	3	1	82014	73812600
4	1	2	1451895	1306705500
5	2	2	1090597	981537300
6	3	2	875961	788364900
7	1	3	2739	2465100
8	2	3	857739	771965100
9	3	3	29741848	25147663200

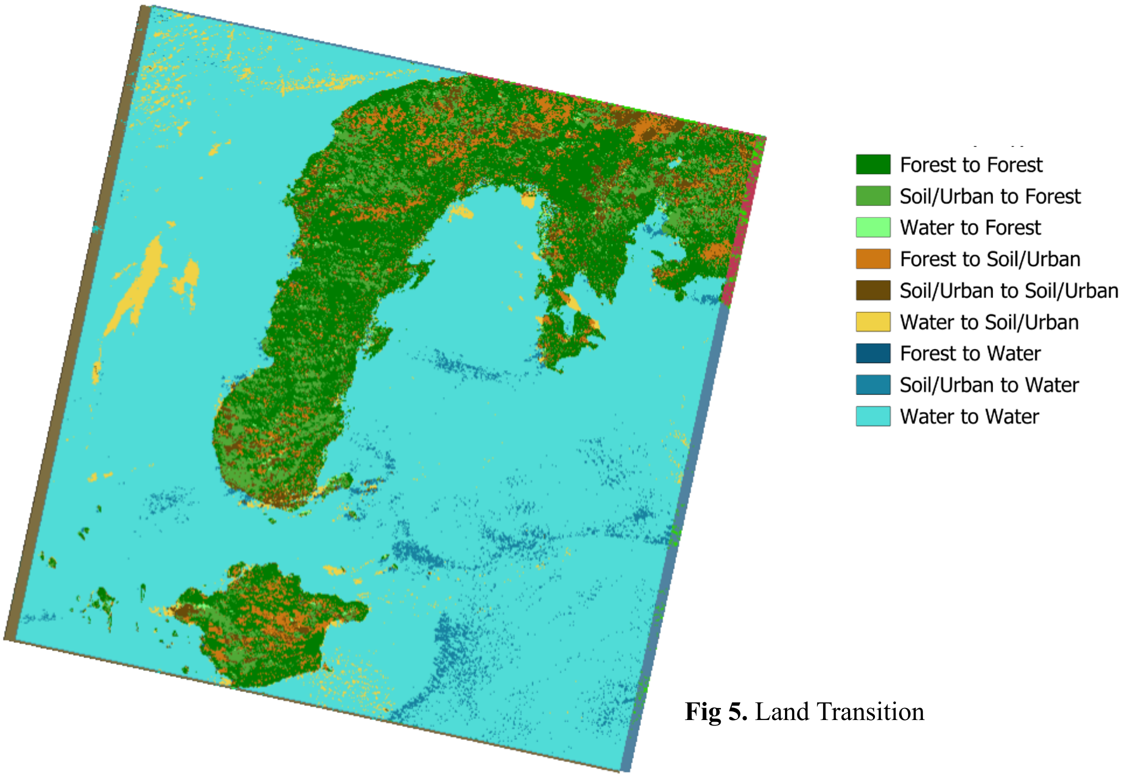

Fig 5. Land Transition

5 Conclusion

In this study, the land cover changes in the Zamboanga Peninsula over the period 2014 to 2024 were analyzed using remote sensing data, specifically focusing on transitions between forest, soil/urban, and water classes. The cross-classification output provides a comprehensive view of these transitions, highlighting significant shifts in land cover. For instance, areas marked as forest in 2014 have transitioned to urbanized or agricultural land (Forest to Soil/Urban), while some urbanized zones have reverted to forest (Soil/Urban to Forest), and water bodies have been encroached upon by urban or agricultural expansion (Water to Soil/Urban). The cross-classification table quantifies these shifts, offering both pixel counts and the corresponding area measurements, which represent the magnitude of change across the landscape.

These observed transitions can be pivotal in predicting future land use dynamics. By understanding how land cover has changed over the past decade, we can identify trends that may continue or accelerate in the future. For example, areas that have shown consistent deforestation (Forest to Soil/Urban) may continue to face urban expansion or agricultural development, while regions with water body loss could indicate vulnerability to further encroachment or drying.

By modeling these trends, decision-makers can better plan for sustainable urban development, conservation efforts, and environmental protection strategies to mitigate the adverse effects of uncontrolled land use changes.

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Youtube Video Link: https://youtu.be/RTsYrv_hEws?si=WsI8bxO-TfuZnUF5