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Ecological Zoning for Sustainable Development: A Case Study of the Momase Region, East and West Sepik Provinces of Papua New Guinea

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Abstract:- This research paper explores the significance of ecological zones in the context of sustainable development, focusing on the Momase Region in Papua New Guinea. The paper discusses the benefits of ecological zones, their applications, the unique ecological diversity in the Momase Region, factors influencing ecological zoning, and the creation of a comprehensive ecological zones map. The study emphasizes the role of such mapping efforts in the ongoing EU-STREIT Programme, showcasing how ecological insights can contribute to rural development and economic growth.

I. INTRODUCTION

In the pursuit of advancing rural development in the East and West Sepik Provinces of Papua New Guinea (PNG), the European Union (EU) is providing financial assistance to the implementation of a one-United Nations programme – Support to Rural Entrepreneurship Investment and Trade (STREIT) programme. This initiative, led by the Food and Agriculture Organization (FAO) of the United Nations, recognizes the paramount importance of understanding the diverse ecological zones that shape the project area.

At the core of this transformative endeavour is the meticulous demarcation and mapping of ecological zones, serving as a foundational tool for sustainable development. This comprehensive mapping effort incorporates data on rainfall, altitude, landforms, and vegetation, enabling a nuanced understanding of the environmental dynamics within the East and West Sepik Provinces. Delving into the intricacies of these ecological zones, it becomes evident that this information transcends scientific abstraction, evolving into a practical and indispensable resource essential for achieving the EU-STREIT programme's objectives.

As the EU-STREIT Programme continues its mission to enhance rural livelihoods and foster economic growth, the ecological zone map emerges as a dynamic tool. It not only provides a scientific understanding of the landscape but also serves as a practical roadmap for impactful interventions. Through collaborative efforts with FAO and esteemed partners, the project strategically leverages this ecological insight to pave the way for a more resilient, inclusive, and sustainable future for the communities in the East and West Sepik Provinces of Papua New Guinea.

II. LITERATURE REVIEW

The concept of ecological zones has been widely recognized and utilized in environmental science, ecology, and conservation. The literature emphasizes the following key aspects:

➢ *Benefits of Ecological Zones*

- *Biodiversity Conservation*

Ecological zones provide a crucial framework for understanding and conserving biodiversity. The identification of unique species combinations in different zones aids in prioritizing conservation efforts (Millennium Ecosystem Assessment (MEA), 2005; Olson et al., 2001).

- *Ecosystem Management*

Categorizing areas into ecological zones allows for informed decisions on resource allocation, habitat protection, and restoration projects, contributing to effective ecosystem management (Sala et al., 2000).

- *Climate Studies*

Ecological zones contribute valuable information to climate studies, helping identify regions with similar climate characteristics. This data aids in understanding climate change patterns and predicting future trends (Sala et al., 2000).

- *Research and Education*

Acting as a foundation for studies on species distribution, ecosystem dynamics, and environmental changes, ecological zones serve as an educational tool, enlightening students about the diversity of ecosystems (Turner et al., 2015).

- *Policy Development*

Governments and environmental organizations use ecological zone data to formulate policies related to land use, conservation, and sustainable resource management (CBD, 2010).

➢ *Uses of Ecological Zone Data*

- *Conservation Planning*

Conservationists use ecological zone data to identify priority areas for conservation efforts, safeguarding habitats with high biodiversity, endangered species, or unique ecosystems (MEA, 2005).

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- *Land Use Planning*

Urban and regional planners utilize ecological zone data to make informed decisions about land use, infrastructure development, and zoning regulations, minimizing the impact on sensitive ecosystems (Turner et al., 2015).

- *Natural Resource Management*

Ecological zone information guides the sustainable management of natural resources such as water, soil, and forests, ensuring a balance between human needs and ecosystem preservation (MEA, 2005).

- *Climate Change Assessments*

Ecological zones play a crucial role in assessing the impact of climate change on different regions, offering insights into how ecosystems respond to various climate-related factors (Sala et al., 2000).

- *Restoration Projects*

Ecological zone data aids in planning and implementing ecosystem restoration projects, focusing on areas experiencing degradation or loss of biodiversity (Olson et al., 2001).

- *Monitoring Environmental Changes*

By monitoring changes in ecological zones over time, scientists can identify shifts in climate, habitat loss, or invasive species' impact, informing adaptive management strategies (Turner et al., 2015).

➢ *Ecological Diversity in Momase Region, Papua New Guinea*

The Momase Region of Papua New Guinea showcases diverse ecological zones influenced by variations in topography, climate, and vegetation. The region encompasses several distinct ecological zones, each contributing to the richness of its environmental tapestry.

- *Exceptionally High Rainfall Forested Zones*

Characterized by lush forests and found in lowland to midland transition zones with hills and ridges, this zone plays a vital role in shaping the unique ecological features of the Momase Region.

- *Extreme and Extremely High Rainfall Zones*

Impacted by intense rainfall, these zones, located in hills, ridges, and volcanic cones, support diverse land uses, contributing to the overall resilience and diversity of the ecosystem.

- *High Rainfall Forested Zones and Land Use*

Encompassing lowland to midland transition zones and lowland zones, this zone features high rainfall, forests, and various land use activities, creating a dynamic ecological makeup.

- *Moderate Rainfall Forested Zones and Land Use*

Defined by moderate rainfall, this zone covers lowland to midland transition zones and lowland zones, showcasing the interaction between land use activities and forests.

- *Very High Rainfall Zones with Land Use and Forests*

Experiencing very high rainfall levels, this zone features diverse land uses in conjunction with forests, adding complexity and richness to the ecological dynamics.

➢ *Factors Influencing Ecological Zoning*

Using rainfall, altitude, landforms, and vegetation data is a common and effective approach to demarcate ecological zones. These factors play crucial roles in shaping the environment and determining the types of ecosystems that can thrive in a particular area.

- *Rainfall*

A key determinant of water availability, rainfall influences vegetation types, overall biodiversity, and the presence of lush forests or arid regions within ecological zones.

- *Altitude*

Crucial in influencing temperature and atmospheric pressure, altitude contributes to the formation of altitudinal zones or life zones, each supporting distinct ecosystems.

- *Landforms*

Diverse landforms, such as hills, ridges, plateaux, plains, and volcanic cones, impact soil composition, drainage patterns, and microclimates, contributing to the ecological diversity of different zones.

- *Vegetation*

Indicative of prevailing ecological conditions, the types of vegetation present in an area provide insights into climate, soil, and water conditions, aiding in the identification of ecological zones.

III. RESULTS AND DISCUSSION

➢ *Ecological Zones in the Momase Region*

The comprehensive mapping efforts in the Momase Region have yielded a detailed understanding of the ecological zones within the East and West Sepik Provinces. The amalgamation of rainfall, altitude, vegetation, and landforms data has resulted in the identification of distinct ecological zones, each contributing uniquely to the region's environmental tapestry.

➢ *Rainfall-Based Ecological Zones*

The Rainfall Map reveals five main ecological zones based on annual precipitation levels, each characterized by specific environmental features and land uses:

Table 1 Rainfall-Based Ecological Zones

Ecological Zone	Characteristics
Exceptionally High Rainfall Forested Zones	Marked by exceptionally high levels of rainfall, fostering the development of lush forests. Typically situated in lowland to midland transition zones with hills and ridges.
Extreme and Extremely High Rainfall Zones	Zones impacted by intense rainfall, located in hills, ridges, and volcanic cones. Support diverse land uses, contributing to the overall resilience and diversity of the ecosystem.
High Rainfall Forested Zones and Land Use	Encompass lowland to midland transition zones and lowland zones, featuring high rainfall, forests, and various land use activities, creating a dynamic ecological makeup.
Moderate Rainfall Forested Zones and Land Use	Defined by moderate rainfall, covering lowland to midland transition zones and lowland areas. Showcases the interaction between land use activities and forests.
Very High Rainfall Zones with Land Use and Forests	Experience very high rainfall levels, featuring diverse land uses in conjunction with forests. Adds complexity and richness to the ecological dynamics of this zone.

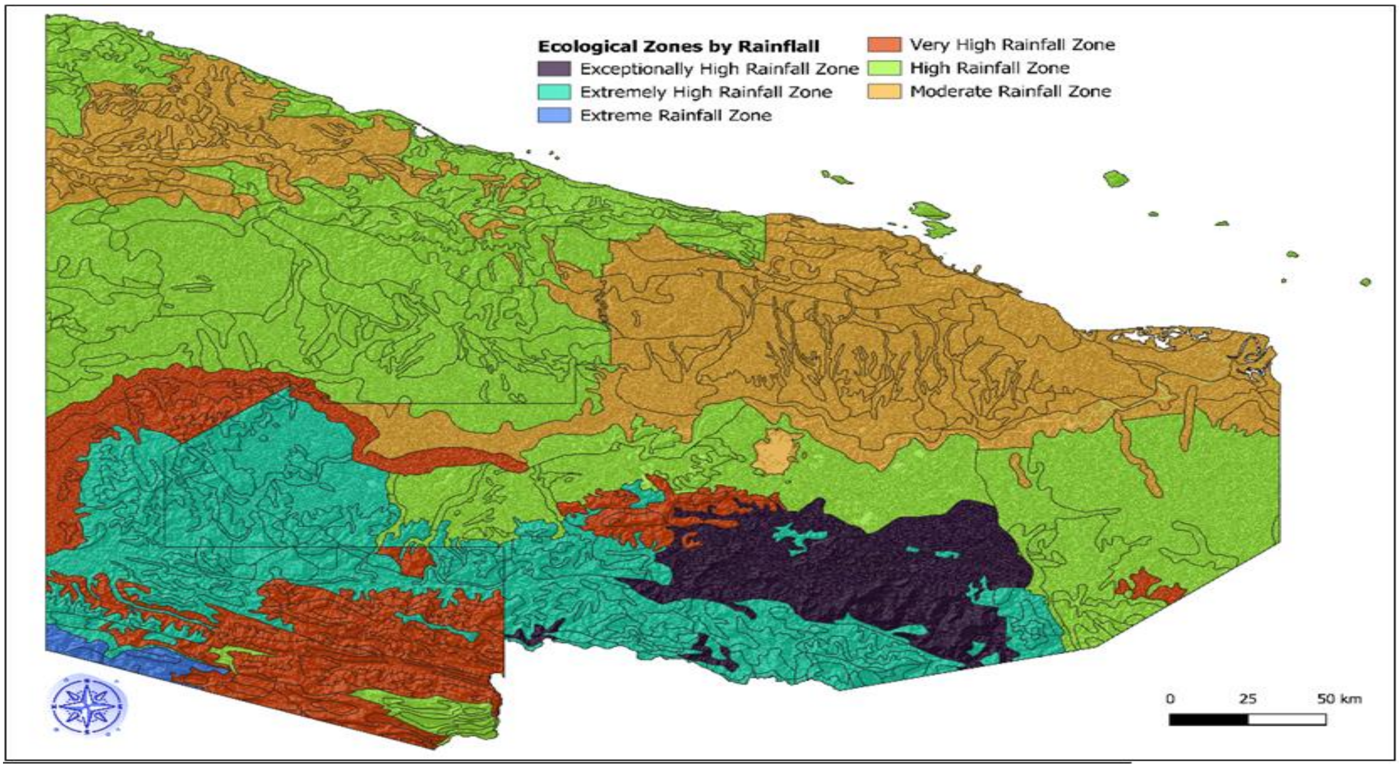


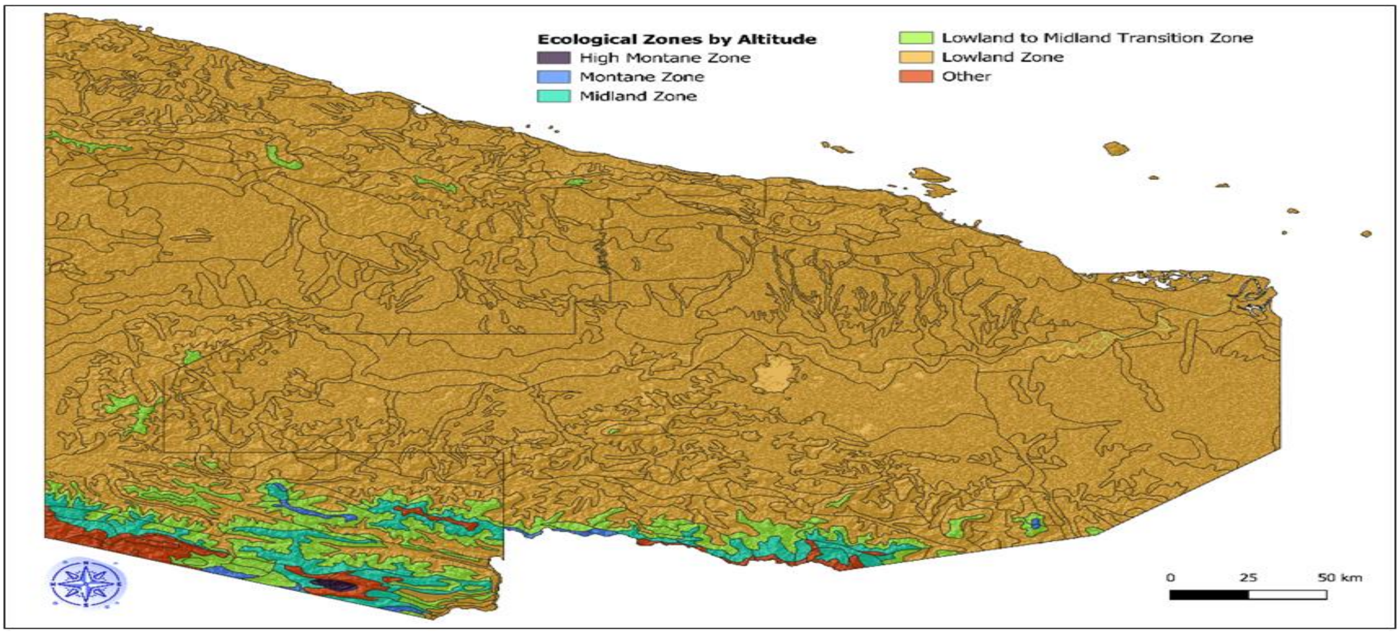
Fig 1 Rainfall-Based Ecological Zones

➢ *Altitude-Based Ecological Zones*

The Altitude Map identifies six ecological zones based on elevation, each characterized by specific temperature regimes and vegetation types:

Table 2 Altitude-Based Ecological Zones

Ecological Zone	Characteristics	Potential Altitude Range
High Montane Zone	Alpine conditions with colder temperatures, snow-capped peaks, glaciers, and alpine vegetation.	3,500 meters (11,500 feet) and above
Montane Zone	Cooler temperatures than lowland areas, featuring diverse vegetation adapted to hilly and mountainous terrain.	1,000 to 3,500 meters (3,300 to 11,500 feet)
Midland Zone	Moderate temperatures with a mix of vegetation types, including both mountain-adapted and lowland species.	500 to 1,000 meters (1,600 to 3,300 feet)
Lowland to Midland Transition Zone	Transitional features between lowland and midland elevations, with a diverse mix of vegetation types.	100 to 500 meters (300 to 1,600 feet)
Lowland Zone	Warmer temperatures, typically supporting tropical or subtropical vegetation adapted to low elevations.	0 to 100 meters (0 to 300 feet)
Other	This category may include areas with unique characteristics not fitting precisely into the main altitude-based zones.	-



➢ *Vegetation-Based Ecological Zones*

The Vegetation Map delineates five main vegetation classes, providing insights into the diverse ecosystems shaped by climate, topography, and human influence:

Table 3 Vegetation-Based Ecological Zones

Vegetation Class	Characteristics
Forest	Dense coverage of trees and often diverse plant life, providing habitat for various wildlife and contributing to biodiversity.
Land Use	Areas modified or managed by human activities for specific purposes, such as agriculture, urban development, or infrastructure.
Land with Sparse Vegetation	Areas with limited vegetation cover, including grasslands, shrublands, or areas where environmental conditions limit the growth of dense plant cover.
Mangrove	Coastal ecosystems characterized by salt-tolerant trees and shrubs, vital for protecting coastlines and providing habitat for diverse marine life.
Other	This category may include areas with unique or specific characteristics that don't fit precisely into the main vegetation classes.

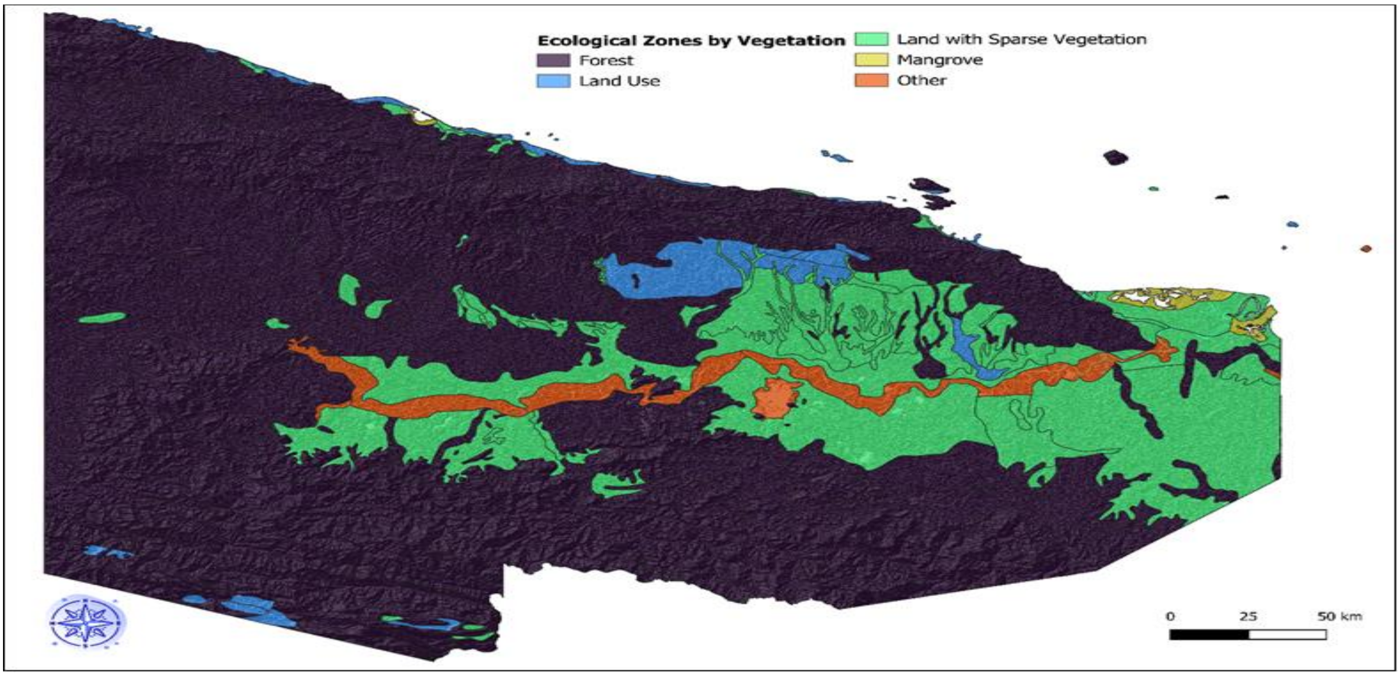


Fig 3 Vegetation-Based Ecological Zones

➢ *Landforms-Based Ecological Zones*

The Landforms Map illustrates the geological diversity within the Momase Region, identifying various landforms and their characteristics:

Table 4 Landforms-Based Ecological Zones

Landform	Characteristics
Alluvial Plains and Floodplains	Formed by sediment deposition from rivers; fertile soils support diverse ecosystems; prone to periodic flooding.
Coastal Plains and Swamps	Low-lying areas along coastlines influenced by tides; home to estuaries, mangroves, and diverse wetland flora and fauna.
Dissected Alluvial and Volcanic Fans	Varied landscapes shaped by river dynamics; intricate patterns result from erosion and sediment transport.
Hills and Ridges	Elevated terrains creating scenic vistas; impact local weather patterns; often support unique flora and fauna.
Karst Plateaux and Volcanic Cones	Karst regions feature limestone landscapes with caves and sinkholes; volcanic cones exhibit conical shapes from past eruptions.
Lakes	Water-filled basins supporting aquatic life; play crucial roles in regional hydrology and biodiversity.
Relict Alluvial and Karst Plains	Ancient plains reflecting geological history; reveal past environmental conditions through their preserved features.
Swamps and Wetlands	Waterlogged areas with standing water; vital for water filtration, flood control, and habitat for specialized species.
Volcanic Plateaux and Karst Regions	Shaped by volcanic or karstic processes; showcase unique geological formations, such as limestone features or remnants of past volcanic activity.

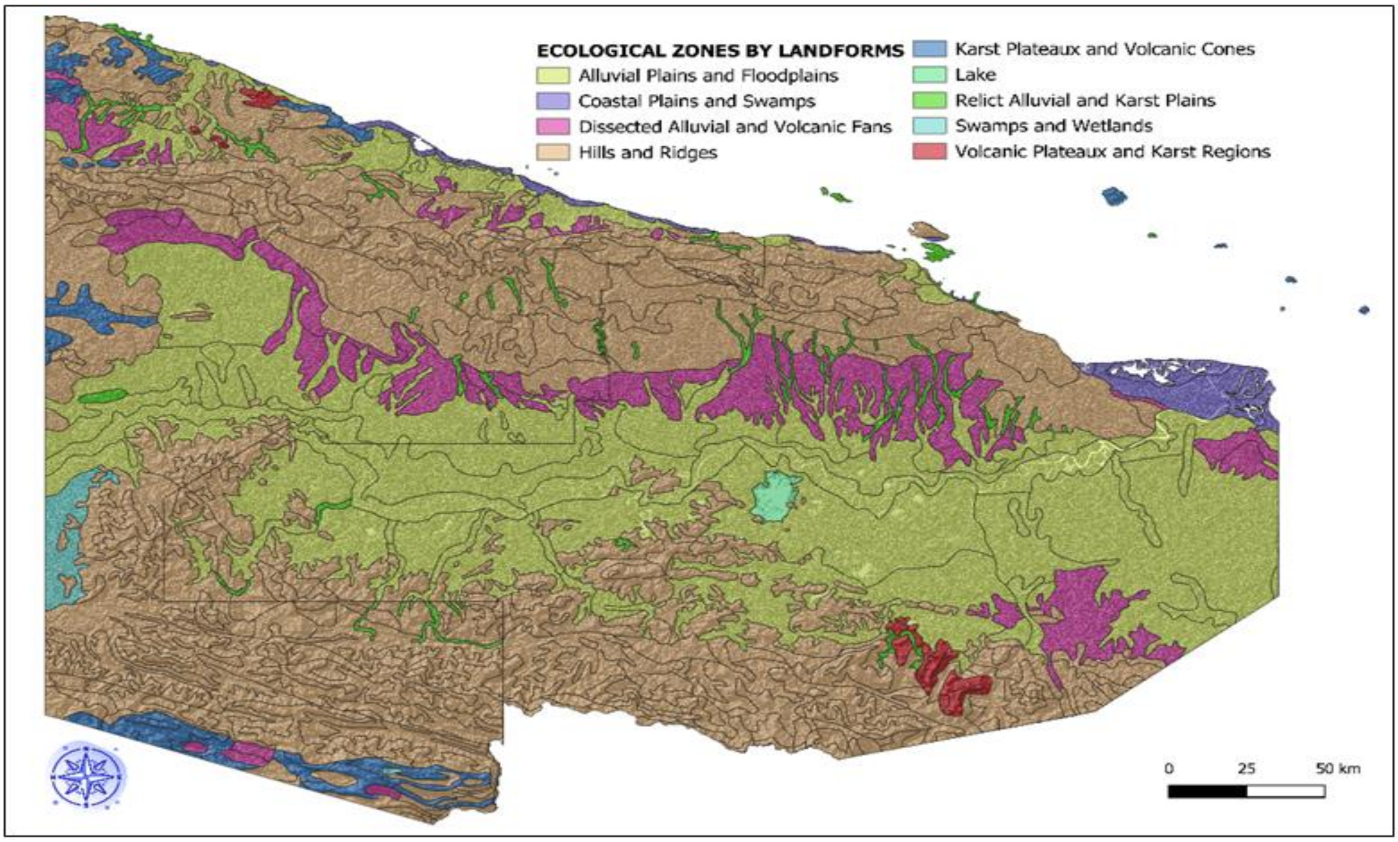


Fig 4 Landforms-Based Ecological Zones

➢ *Ecological Zones Map of East and West Sepik Province*

The amalgamation of rainfall, altitude, vegetation, and landforms births a diverse tapestry of ecological zones. QGIS weaves these threads into a comprehensive map. The following are a brief exploration of the classes born from this synthesis:

- *Exceptionally High Rainfall Forested Zones:*

Characteristics: Lush forests thrive in lowland to midland transition zones adorned with hills and ridges. Exceptional rainfall fosters a unique ecological haven.

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- *Extreme and Extremely High Rainfall Zones:*
  Characteristics: Intense rainfall defines this zone, impacting forested areas on hills, ridges, and volcanic cones. The landscape, embracing diverse land uses, echoes resilience.

- *High Rainfall Forested Zones and Land use:*
  Characteristics: Abundant rainfall graces lowland to midland transition zones and lowland areas. Forests interlace with karst plateaux, volcanic cones, and hills, coexisting with varied land uses.

- *Moderate Rainfall Forested Zones and Land use:*
  Characteristics: Moderate rainfall characterizes lowland to midland transition zones and lowlands. Forested realms embellish hills, ridges, and volcanic landscapes, intertwining with human-influenced land uses.

- *Very High Rainfall Zones with Land Use and Forests:*
  Characteristics: A wealth of rainfall blesses this zone, featuring diverse land uses. Forests grace lowland and midland transition zones, accompanied by hills, ridges, and volcanic cones, enriching the ecological narrative.

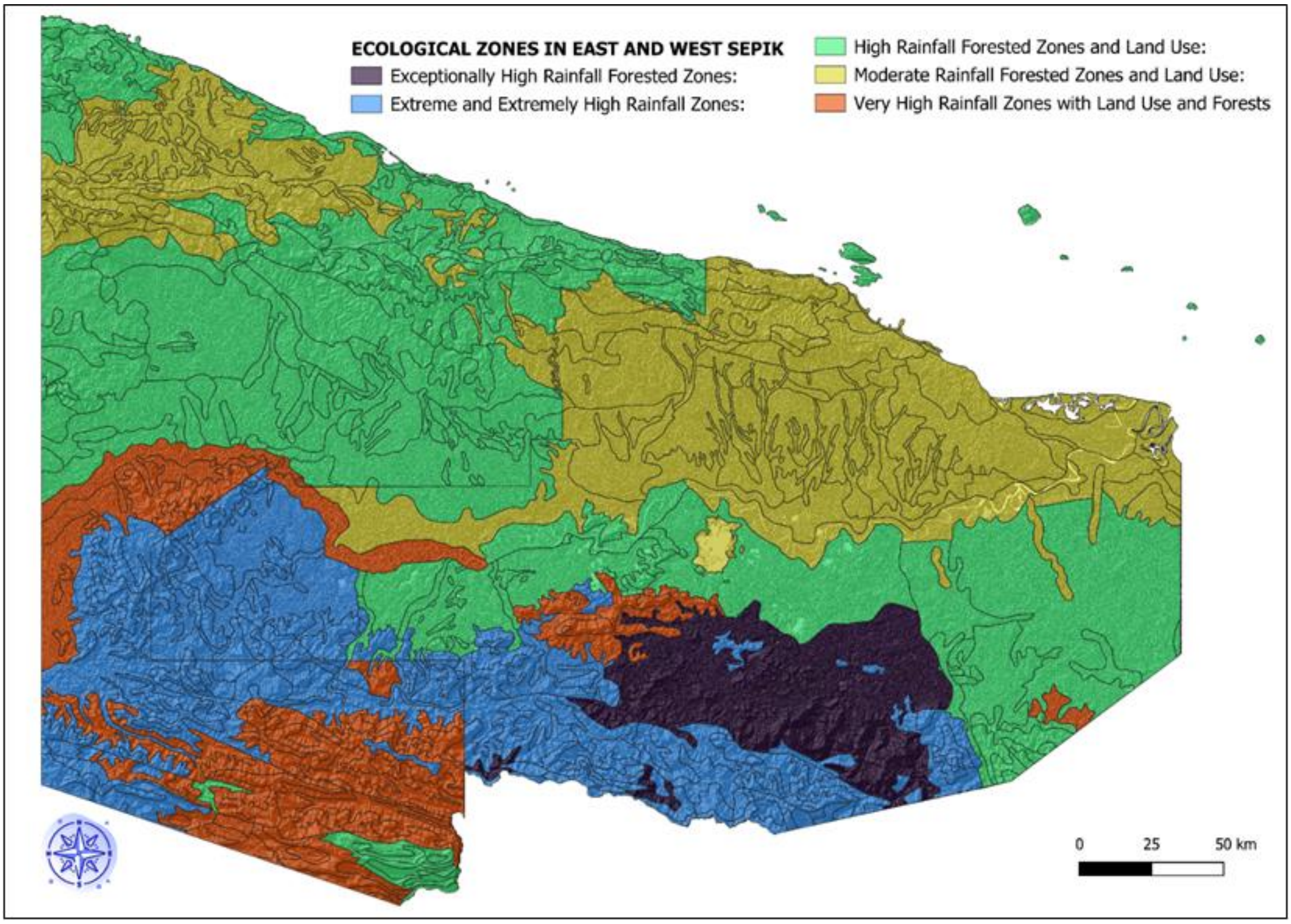

Fig 5 Ecological Zones Map of East and West Sepik Province

- *Spatial Distribution of Public Facilities and Census units in Each Ecological Zones*

The distribution of health and educational facilities across various ecological zones in the Momase Region reveals intriguing patterns, shedding light on the strategic placement of these critical services.

Table 5 Spatial Distribution of Public Facilities and Census units in Each Ecological Zones

Facility Type	Exceptional High Rainfall Forested Zones	Extreme and Extremely High Rainfall Zones	Very High Rainfall Zones with Land Use and Forests	High Rainfall Forest Zones and Land Use	Moderate Rainfall Forest Zones and Land Use
Health Facilities	8 (1.9%)	15 (3.5%)	27 (6.3%)	184 (43.2%)	192 (45.1%)
Census Units	42 (1.9%)	98 (4.5%)	128 (5.8%)	819 (37.2%)	1114 (50.6%)
Primary Schools	10 (2.3%)	9 (2.1%)	27 (6.2%)	186 (42.8%)	203 (46.7%)
High Schools	0 (0.0%)	0 (0.0%)	1 (3.8%)	11 (42.3%)	14 (53.9%)
Vocational Schools	0 (0.0%)	0 (0.0%)	1 (5.0%)	14 (70.0%)	5 (25.0%)
Airstrips/Airports	5 (4.8%)	9 (8.6%)	18 (17.1%)	48 (45.7%)	25 (23.8%)

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Notably, High Rainfall Forest Zones and Land Use stand out as focal points for the concentration of health facilities and educational institutions. This zone, characterized by abundant rainfall and diverse land use activities, accounts for a substantial percentage of health facilities (43.19%) and educational units, including census units (37.21%) and primary schools (42.76%). The prominence of High Rainfall Forest Zones and Land Use suggests a deliberate alignment of infrastructure with the region's ecological features, emphasizing the importance of these zones in supporting community services.

Furthermore, the analysis unveils a strategic approach to transportation, as Airstrips/Airports are notably concentrated in areas with Extreme and Extremely High Rainfall (8.57%) and High Rainfall Forest Zones and Land Use (45.71%). This indicates a thoughtful consideration of ecological factors in establishing transportation hubs, potentially facilitating accessibility to remote areas. Conversely, Moderate Rainfall Forest Zones and Land Use also play a significant role in hosting high schools (42.31%) and vocational schools (70.00%). This distribution pattern underscores the adaptability of educational facilities to varying ecological conditions, showcasing a nuanced approach to infrastructure development that considers both environmental dynamics and community needs.

Overall, these insights, including the strategic placement of census units within these ecological zones, provide a valuable foundation for future planning, emphasizing the synergy between ecological considerations and the strategic placement of essential services for the sustainable development of the Momase Region.

IV. CONCLUSION

In summary, this study underscores the intricate interplay of ecological zones in the Momase Region, Papua New Guinea. The Ecological Zones Map, born from comprehensive mapping efforts, contributes to a nuanced understanding of the region's environmental dynamics, providing a valuable resource for sustainable development initiatives.

The identified ecological zones form a crucial foundation for informed decision-making, conservation efforts, and the pursuit of resilient, inclusive, and sustainable futures for the communities in the East and West Sepik Provinces.

By integrating scientific insights with practical applications, the Ecological Zones Map emerges as a dynamic tool for the EU-STREIT Programme. It reinforces the program's mission to enhance rural livelihoods and foster economic growth in Papua New Guinea. The presented results highlight the importance of ecological knowledge in guiding transformative endeavours and building a sustainable future for both nature and humanity.

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