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ANALYZING AGRICULTURAL SUITABILITY USING GEOGRAPHIC INFORMATION SYSTEM (GIS) AND REMOTE SENSING

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ABSTRACT

This study addresses the persistent gap in localized and fine-scale agricultural suitability assessments in the Philippines by integrating Geographic Information System (GIS) and remote sensing techniques with a multi-criteria decision framework. While previous studies have explored spatial planning using limited biophysical parameters, this research introduces a novel integration of geomorphological, hydrological, climatic, and infrastructural variables—including slope, elevation, soil type, rainfall, topographic wetness index (TWI), land use/land cover (LULC), temperature, and proximity to roads and streams—using the Analytical Hierarchy Process (AHP) and Weighted Multi-Criteria Analysis (WMCA). Applied in Southern Leyte, the study reveals that 52.59% of the province's land is of very low suitability due to poor soil quality, extreme temperature variations, and limited water access, while only 2.04% is classified as very highly suitable. This fine-scale, evidence-based spatial model offers practical value: farmers can optimize crop selection and field layout; land use planners can align zoning strategies with biophysical constraints; and policymakers can prioritize irrigation and climate-adaptive interventions in vulnerable areas. The findings contribute not only to enhancing agricultural productivity and resource efficiency but also to advancing sustainable land management, mitigating climate risks, and supporting national targets under SDG 2 (Zero Hunger) and SDG 15 (Life on Land). By providing an empirically grounded, locally tailored decision support tool, this study helps bridge the gap between geospatial research and strategic agricultural development planning.

Keywords: Agricultural Suitability; GIS; Remote Sensing; Geomorphological Parameters; Hydrological Analysis; Spatial Planning; Land Use Management; Sustainable Agriculture

INTRODUCTION

The transformation of landscape structures significantly influences ecosystem functions, particularly in terms of nutrient dynamics, energy partitioning, and hydrologic flows (Baker, 1995). The magnitude of these changes has raised concerns about landscape sustainability and the capacity of ecosystems to provide essential services for human well-being (Plieninger et al., 2016). Studies have shown that land-use changes have led to a significant decline in ecosystem service values (Qiu et al., 2019), with agricultural land-use change contributing to food insecurity and an inability to meet food needs over the past decades (Bonye et al., 2021). Additionally, data indicate that land surface transformations occur at varied intensities, with urban expansion accounting for nearly 80% of land conversion (van der Zanden et al., 2016). The increasing pressure from urbanization, industrialization, and climate change has made it imperative to develop systematic approaches to assess, monitor, and manage agricultural land use effectively. Agriculture remains one of the most fundamental sectors for human survival, providing food, raw materials, and economic stability (García-Díez., et al., 2021). However, land suitability for agricultural purposes depends on environmental factors such as soil quality, topography, climate, and water availability. Poor land-use planning and unsustainable agricultural expansion often lead to land degradation, reduced productivity, and increased vulnerability to climate-related disasters (Li, 2021; Azadi et al., 2022). Integrated assessments using various models have been developed to predict changes in agricultural demand and analyze land use change trajectories (Verburg et al.,2005). Geographic Information Systems (GIS) and remote sensing have proven to be powerful tools in evaluating land suitability by integrating spatial data, satellite imagery, and environmental parameters. Through remote sensing, high-resolution satellite imagery can be used to analyze vegetation health, soil moisture levels, and climate conditions. GIS allows for spatial modeling and analysis of factors such as elevation, slope, and hydrological flow, which are critical in determining the suitability of land for different types of crops (Ali, 2024). Southern Leyte, a province in the Philippines, is highly dependent on agriculture as a primary economic activity, making the identification of suitable agricultural lands critical for long-term productivity and environmental resilience. However, climate variability, increasing land demand, and poor land management practices threaten its agricultural viability. In response, GIS and remote sensing offer a data-driven approach to assessing land suitability, helping to balance agricultural productivity with environmental conservation. By leveraging these technologies, optimizing land use, enhancing agricultural planning, and mitigating risks associated with land degradation and climate change is possible. By incorporating geospatial analysis in agricultural planning, this research aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 15 (Life on Land). The study promotes sustainable agricultural practices (SDG 2) by identifying optimal farmland areas, contributing to enhanced food security and agricultural productivity. Additionally, it supports responsible land management and biodiversity conservation (SDG 15) by guiding the sustainable use of land resources and preventing environmental degradation. The findings will contribute to local and national policies aimed at achieving agricultural resilience and sustainability amidst environmental challenges, thereby enhancing food security and ecological balance. This study analyzes land use change dynamics to determine suitable agricultural zones in Southern Leyte using GIS and remote sensing techniques. Specifically, it seeks to (i) analyze the geomorphological, topographical, and hydrological characteristics of the province and (ii) determine the most suitable agricultural areas based on spatial analysis techniques.

MATERIALS AND METHODS

This study employed descriptive and quantitative non-experimental research design, integrating Geographic Information System (GIS)-based techniques and statistical analysis to assess agricultural land suitability in Southern Leyte. The study used Analytical Hierarchy Process (AHP) and Weighted Multi-Criteria Analysis (WMCA) to evaluate topographical, hydrological, and geomorphological parameters affecting agricultural suitability. These methodologies help determine relationships between variables and assign suitability levels based on multiple factors (Denzin et al., 2017). Various geospatial datasets were acquired from authoritative sources to ensure the accuracy and reliability of the agricultural suitability assessment. These datasets provide essential information on topographical, hydrological, land use, infrastructure, and administrative boundaries, which are critical for evaluating the suitability of agricultural zones in the study area. The study incorporated a range of spatial datasets to analyze the environmental and infrastructural characteristics of the study area. A Digital Elevation Model (DEM) with a 30-meter resolution was acquired from USGS.gov for topographical and hydrological analysis, offering essential insights into slope and elevation variations (Mukherjee et al., 2013). Additionally, soil type data was obtained from the Bureau of Soils and Water Management (BSWM) as a raster layer for classification. To assess precipitation's influence on the landscape, a 10-year historical precipitation dataset (2014–2023) with a 1 km² spatial resolution was sourced from WorldCom.org. The study also considered land use and infrastructure data. The proximity of irrigation and road networks was determined using remote sensing techniques with data from OpenStreetMap (OSM) and ESRI maps. Furthermore, land use and land cover (LULC) classification was conducted using satellite imagery from USGS (2023), following established classification methods (Satellite Image Classification Methods and Techniques: A Survey, 2021). Administrative boundary data was obtained from the National Mapping and Resource Information Authority (NAMRIA) to ensure accurate geographic referencing. This dataset provided official delineations of municipal and barangay boundaries within the study area, ensuring precision in spatial analysis. The study used a rigorous methodological approach to preprocessing satellite imagery, classify land use and land cover (LULC), conduct suitability analysis, and validate results. Radiometric and atmospheric corrections were applied before classification to enhance the quality of satellite images. Radiometric correction addressed sensor-based distortions, refining reflectance values, while atmospheric correction removed interferences such as haze, aerosols, and water vapor. These preprocessing steps significantly improved image quality, ensuring precise land cover classification and spatial analysis (Enhancing the Quality of Satellite Images by Preprocessing and Contrast Enhancement, 2017). For LULC classification, the study utilized the semi-automatic plugin in the Quantum Geographic Information System (QGIS). Machine learning algorithms were employed to analyze spectral signatures from satellite imagery, enabling the categorization of agricultural lands, forests, urban areas, and water bodies. This classification formed the foundation for further spatial analysis, leveraging a cost-effective, efficient, and highly accurate mapping approach (Congedo, 2016). Multi-criteria decision-making techniques were applied to assess agricultural suitability, specifically the Analytical Hierarchy Process (AHP) and Weighted Multi-Criteria Analysis (WMCA). AHP assigned relative importance to environmental and infrastructural factors, including slope, elevation, soil type, precipitation, distance to irrigation, and land cover, allowing for systematic and objective decision-making (Cengiz & Akbulak, 2009). Meanwhile, WMCA refined raster pixel values, enhancing interpolation processes to generate spatially accurate suitability maps. By integrating expert judgment with computational modeling, this method improved the precision of land suitability analysis (Yılmaz, 2022). Finally, validation and accuracy assessment ensured the reliability of the classification and suitability results. Ground truth data collection involved field verification to compare land conditions with satellite-based classifications. Statistical validation metrics were used to evaluate classification performance, including overall accuracy and the kappa coefficient. The overall accuracy indicated the percentage of correctly classified pixels, while the kappa coefficient measured classification agreement beyond chance. These validation techniques confirmed the robustness of the analysis, reinforcing the accuracy and applicability of the generated agricultural suitability maps (Rwanga & Ndambuki, 2017). Figure 1 outlines the methodological approach for determining suitable agricultural zones using GIS and remote sensing techniques. The process begins with input data collection and preparation, gathering various geospatial and environmental datasets. These datasets include slope, topographic wetness index (TWI), rainfall, elevation, soil type, humidity, land use/land cover (LULC), distance to rivers and creeks, and distance to road networks, which serve as key factors influencing agricultural suitability. Once the data is collected, it undergoes a reclassification process, where raw spatial data is standardized and categorized into suitability classes to ensure uniformity across multiple criteria. The reclassified data is then compiled into suitability layers, representing different environmental conditions affecting land usability. These layers are further analyzed using the Analytical Hierarchy Process (AHP), a decision-making technique that assigns weighted values to each factor, allowing for a structured prioritization of agricultural suitability parameters. Following the AHP-based assessment, the study identifies suitable agricultural zones by integrating the weighted factors into a spatial analysis model. The results are then subjected to model validation and calibration, which involves comparing the generated suitability maps with real-world land cover data and conducting accuracy assessments using ground truthing techniques and statistical validation metrics. This iterative validation process ensures the final agricultural suitability analysis's accuracy, reliability, and effectiveness.

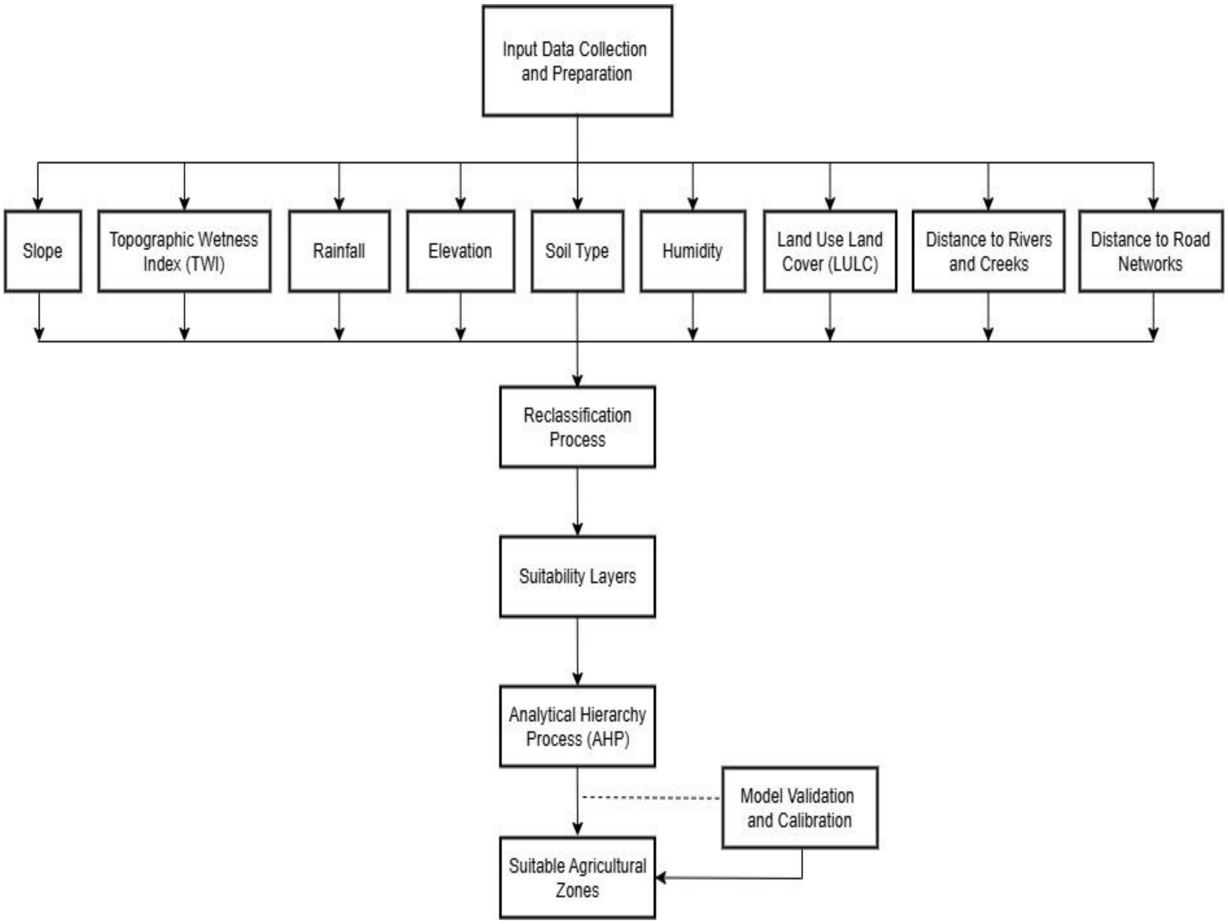

Figure 1: Framework of the Study

Southern Leyte is a province in the Eastern Visayas Region of the Philippines, located at 10°20′N 125°05′E. The province is known for its diverse natural landscapes and rich cultural heritage (Figure 2). It is administratively divided into 18 municipalities and one city, forming part of a double legislative district and further subdivided into 500 barangays. Southern Leyte features a varied topography, including mountains, rolling terrains, forests, pristine beaches, and extensive agricultural lands. The province's economy is primarily driven by agriculture, fishing, and eco-tourism, with its natural beauty and tranquility attracting visitors and fostering sustainable tourism development. Given its strong reliance on agricultural productivity, assessing the suitability of agricultural lands based on geomorphological and hydrological factors is essential for ensuring sustainable land use and long-term agricultural viability.

Figure 2: Map showing the location of the study

RESULTS AND DISCUSSIONS

Table 1 presents the slope classification as shown in the map in Figure 3. of Southern Leyte. Data has shown that 37.94% of the total land area is classified as level to near levels with slope ranges <3%, which covers 63,883.53 ha, and the least is slope ranges of >50%, which comprises .01%, equivalent to 15.81 ha of the total land area. Based on the data analyzed data, this implies that most of the area in Southern Leyte is ideal for agriculture, provided that effective and efficient drainage management is in place to ensure that drainage problems are well addressed during climate extremes. Although typically, the area has less erosion potential due to its flat terrain, this implies suitability for a wide range of crops and other plant species. However, due to its gentle slopes, potential flooding risks may result in water logging, requiring additional drainage-related infrastructures. On the other hand, gentle slopes imply efficient drainage with lands not prone to excessive runoff and reduced soil erosion as compared to steeper slopes, highlighting versatility in crop selection and optimal use of machinery, facilitating larger farm operations with efficiency and reducing manual labor and incurring lower cost operations with higher production. According to Zolekar & Bhagat (2015) slope is one of the physiographic components that can affect agricultural production.

Table 1: Slope suitability classification

Suitability ID	Slope Ranges (%)	Philippine Slope Classification Description	Suitability Classification	Area (ha)	%
1	>50	Very Steep	Very Low	15.81	.01
1	30 - 50	Steep	Very Low	46869.85	27.84
2	18 - 30	Rolling to Moderately Steep	Low	28698.92	17.04
3	8 - 18	Undulating to Rolling	Moderate	22238.23	13.21
4	3 - 8	Gently Sloping to Undulating	High	6677.90	3.97
5	<3	Level to Nearly Level	Very High	63883.54	37.94
		Total		**168384.00**	**100**

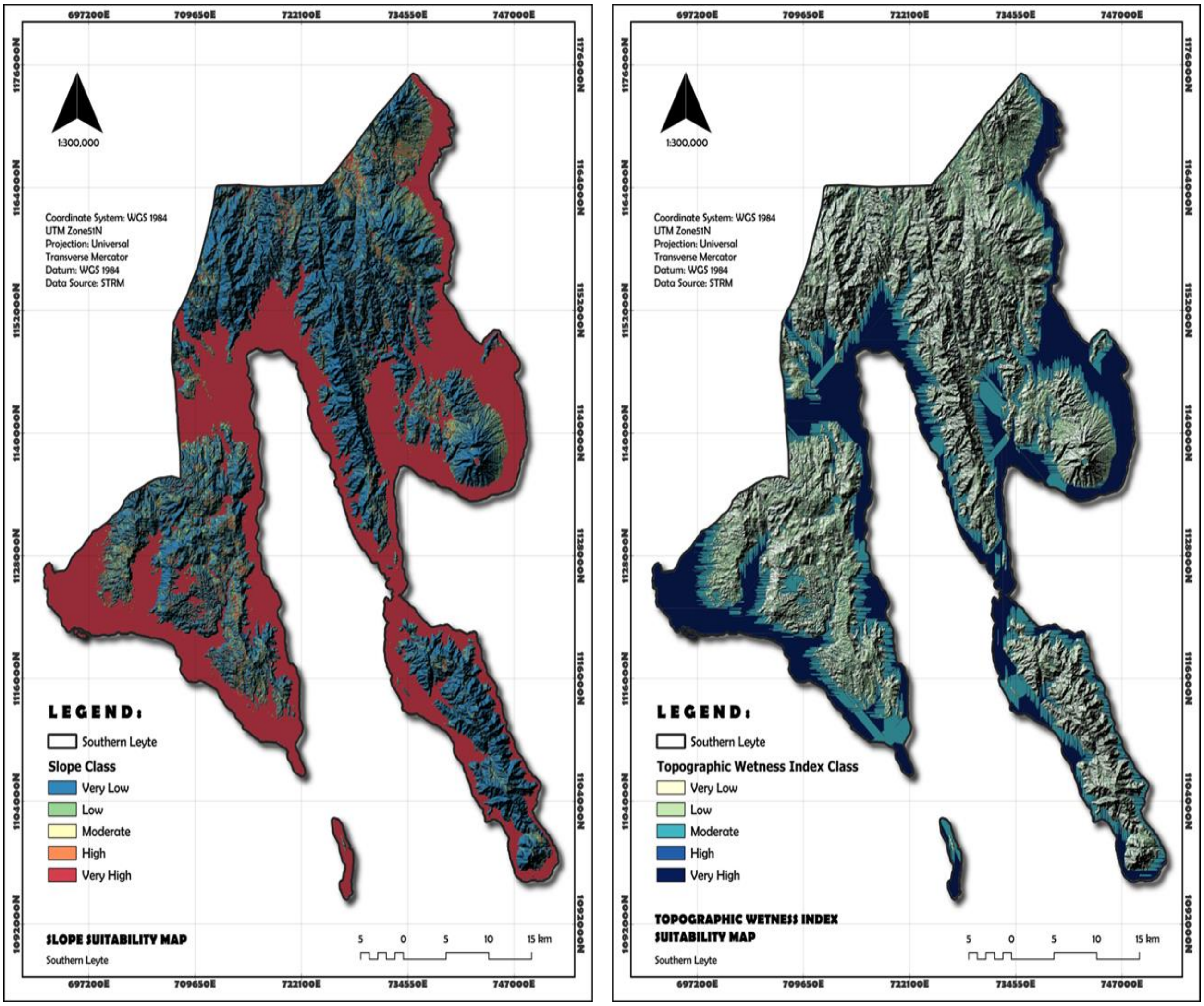

Figure 3: The slope and topographic wetness index (TWI) suitability map

Table 2 presents the study area's Topographic Wetness Index (TWI), as shown in the map in Figure 3. Results show that most areas are classified as moderately low moisture accumulation, with covers 41.85%, equivalent to 70,483.14 ha, and the least are classified as very high moisture accumulation, with .45% and a total land area of 762.99 ha. This implies significant challenges in the agricultural sector requiring strategic agricultural practices, particularly in water management and conservation, especially during prolonged periods of drought. Nonetheless, the need for irrigation-related facilities may be crucial in some areas designated for cultivation as water retention is likely less in most of the study areas. Aside from that, selecting suitable species that are tolerant of less rainfall and species requiring a minimal amount of water is necessary as plants may have the potential to experience stress due to minimal water moisture retention in most of the area. Although this suggests that the area is less prone to water logging due to lower TWI, there is a need for improving soil moisture retention by incorporating soil amendments, installation of water-related support infrastructure like water storage and conservation by building small tanks and retention ponds or sue of mulch and, and adjusting crop selection to well adapted to moderate and moisture condition providing long-term soil benefits. This was supported by Qin et al. (2011) that TWI is a crucial topographic attribute used in precision and agriculture and is designed to quantify the effect of local topography on hydrological processes for modeling spatial distribution of moisture and surface saturation.

Table 2: Topographic wetness index suitability classification

Suitability ID	TWI Ranges	TWI Description	Suitability Classification	Area (ha)	%
1	<5	Well Drained	Very Low	25241.99	14.99
2	5 - 10	Moderately Low Moisture Accumulation	Low	70463.14	41.85
3	10 - 15	Moderate Moisture Accumulation	Moderate	32867.81	19.52
4	15 - 20	High Moisture Accumulation	High	39048.04	23.19
5	>20	Very High Moisture Accumulation	Very High	762.99	0.45
		Total	**168384**	**168384**	**100**

Presented in Table 3 is the rainfall classification of the study area. Data has shown that the majority of the study area is classified as moderate suitability, which comprises 42.27%, equivalent to 38,381.16 ha, and the least is classified as very high suitability, with 3,114.32 ha, comprising 1.85% of the total land area. This implies adequate rainfall in most of the land area, which helps improve soil moisture and health, significantly increasing productivity. However, this requires complementing rainfall with appropriate and efficient rainfall support management and practices to optimize moisture level, which is crucial in soil moisture retention, particularly during prolonged drought. On the other hand, this reduces the likelihood of flooding during normal weather conditions with moderate rainfall received, considering that the area is classified as level to nearly level, which also implies sufficient and nearly enough drainage facilities to address excess water during extreme rainfall events. Although generally, a moderate rainfall classification indicates land can support diverse farming activities, it still requires soil and water management strategies. This includes efficient water management like mulching, which can reduce evaporation during extreme weather conditions, erosion control, and land stabilization incorporating contour farming, aiding in slowing down runoff and reducing water flow velocity, and implementing a system for monitoring climate patterns such as rainfall and temperature to adjust agricultural and farming dynamics. The understanding and characterization of rainfall patterns and spatial distribution is relevant in agricultural productivity and security particularly in areas classified as rainfed agriculture (Nathan et al.,2020).

Table 3: Rainfall suitability classification

Class ID	Suitability ID	Rainfall Ranges (mm)	Suitability Classification	Area (ha)	%
1	1	2970 - 3070	Very Low	23588.82	14.01
2		3070 - 3170			
3	2	3170 - 3270	Low	32116.09	19.07
4		3270 - 3370			
5	3	3370 - 3470	Moderate	71183.12	42.27
6		3470 - 3570			
7	4	3570 - 3670	High	38381.16	22.79
8	5	3670 - 3793	Very High	3114.32	1.85
		Total		**168384**	**100**

Presented in Table 4 are the elevation ranges of the study area as shown in the map in Fig. 4. Results have revealed that 46.21% of the area is classified as very suitable, which covers the 46.21% with a total land area of 77,805.28 ha with elevation ranges of <200 masl and the least and 1.18 of the total land area is classified as very low suitability with 1,989.52 ha with elevation ranges of >800 masl. This indicates that most of the area is categorized as highly suited, considering it is nearly flat terrain and has moderate rainfall classifications. The lower elevation areas typically exhibit warmer temperatures, allowing greater suitability for cultivation. Also, it has a higher tendency to accumulate sediments rich in nutrients, which was associated with its lower elevation characteristics. Although it has a higher potential for flooding associated with its elevation ranges, this can be addressed by implementing efficient and effective drainage management and other related support facilities to address agricultural problems. Generally, high-elevation ranges are characterized by cooler temperatures, reduced atmospheric conditions, and rugged terrain; this can still support agricultural production depending on varied environmental conditions, highlighting the need for adjustments. This includes crop management by selecting species that can thrive in cooler environments, climate resilience, and risk management involving crop and livestock diversification, reducing tendencies of total crop failure linked to climate fluctuation, and risk transfer by considering investment in crop insurance to protect against climate extremes such as prolonged wet and dry periods. Results from the study of Biswas et al. (2008) showing spatial relationships related to nutrient retention affected by elevation reflecting hydrological and soil water content in agricultural landscapes.

Table 4: Elevation ranges suitability classification

Suitability ID	Elevation Ranges (masl)	Classification	Area (ha)	%
1	>800	Very Low	1989.52	1.18
2	600 - 800	Low	9884.79	5.87
3	400 - 600	Moderate	27299.24	16.21
4	200 - 400	High	51405.18	30.53
5	<200	Very High	77805.28	46.21
	Total		**168384**	**100**

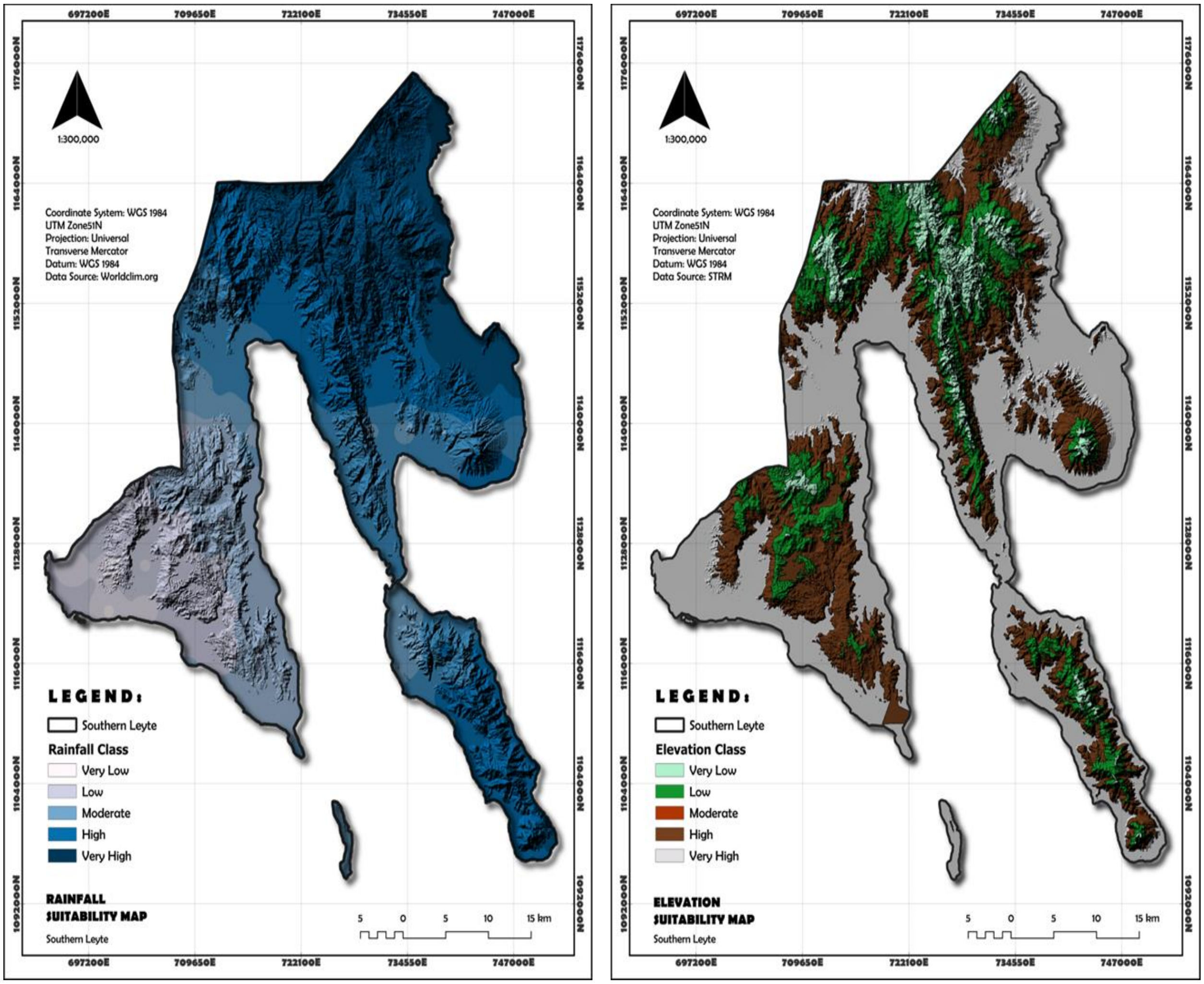

Figure 4: The rainfall and elevation suitability map

Presented in Table 5 is the soil classification suitability of Southern Leyte as shown in the map in Fig. 5. Results have indicated that the majority of soil suitability is categorized as very low comprising the 51.89% or 87366.09 ha. of the total land area which was described as hydrosol, beach sand, rough sand, and rough mountainous land and only 5.59% or 9409.52 ha. of the total land area were considered very highly suitable composed of bantog clay loam, umingan clay loam, and himangayan clay loam. This indicates varying suitability for agriculture, with most of the soil described as less suitable, with limitations like poor drainage, high salinity, high erosion risks, and minimal soil depth preventing root penetration based on the identified soil classification. Although some portions of the study area remain available and indicate high production, these also indicate potential improvements by adding organic matter, proper irrigation and drainage infrastructure, and crop selection, which was ideal for the type of soil in the area. Although the majority of the soil classified presents specific challenges, these also necessitate adjustments in terms of salinity management, especially in areas that tend to be saline, like beach sand, employing techniques aimed to leach salts from the soil and soil enrichment through organic matter improvement improving water holding capacity and nutrient retention, Also, in the face of changing climate, this considers the needs climate resilient crops that can withstand extreme weather conditions and other environmental factors. The improvement of soil quality particularly in marginal lands are imperative in agricultural production (Li et al.,2017).

Table 5: Soil type suitability classification

Suitability ID	Description	Suitability Classification	Area (ha)	%
1	Hydrosol	Very Low	87366.09	51.89
1	Beach sand			
1	Rough stony land			
1	Rough Mountainous land			
2	Faraon clay (Steep phase)	Low	15201.89	9.03
2	Obando fine sand			
3	Taal fine sandy loam	Moderate	15534.66	9.23
3	San Manuel fine sandy loam			
3	Malitbog clay			
3	Faraon - Bolinao complex			
4	San Manuel silt, San Manuel silt loam, San Miguel silt loam	High	40871.35	24.27
4	Umingan clay			
4	Bolinao clay			
4	Madellin clay			
4	Maasin clay			
4	Guimbalaon clay			
4	Luisiana clay			
4	General clay			
5	Bantog clay loam	Very High	9409.52	5.59
5	Umingan clay loam			
5	Himayangan clay loam			
	Total		**168384**	**100**

Presented in Table 6 is the road buffer classification and suitability as presented in Fig. 5. Road buffers are a crucial component in agricultural areas. Results have revealed that the area is classified as very high suitability in terms of its distance from road networks, with 32.68% or 55370 ha indicating minimal risks associated with vehicular traffic and emissions, implying efficient land use and accessibility and minimizing encroachment. On the other hand, 7.69% of the area is classified as moderate suitability, indicating soil and water management issues implying some impartiality of some drainage, which may have led to occasional waterlogging. Also, this means some potential constraints with buffers may be too narrow or incompletely developed, highlighting some encroachment issues. Nonetheless, possible improvements can be carried out to improve suitability by improving drainage systems, increasing vegetation cover, and buffer expansion. Also, considering high suitability, some adjustments like windbreaks and biodiversity features can be enhanced for optimal impact on agricultural productivity. Excellent and efficient road buffers enhance microclimate, wherein vegetation can help mitigate the temperatures in surrounding agricultural fields, reduce tendencies of sudden climate fluctuations, and aid moisture retention, resulting in better moisture accumulation for crops and reducing irrigation needs while improving overall productivity. Results from the study of Dunn et al. (2011) have suggested buffer zones from operational farms capable of achieving contaminant reduction citing 10-m for moderate slope and 20-m for steep slopes fields.

Table 6: Road buffer suitability classification

Suitability ID	Road Buffer	Suitability Classification	Area (ha)	%
5	0 - 500	Very Low	44397.12	9.56
4	500 - 1000	Low	30654.07	18.20
3	1000 - 1500	Moderate	12941.16	7.69
2	1500 - 2000	High	25021.44	14.86
1	>2000	Very High	55370.12	32.88
	Total		**168384**	**100**

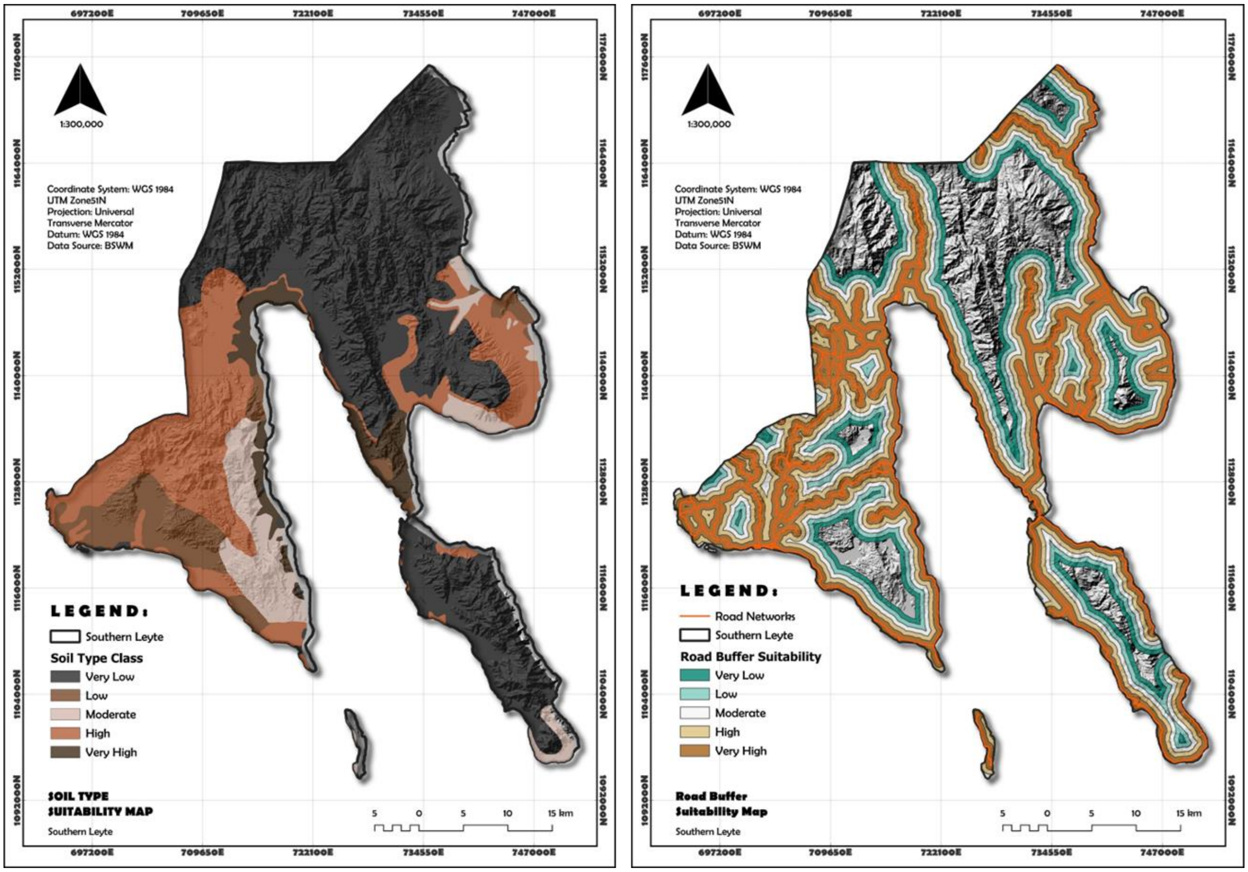

Figure 5: The soil type and road buffer suitability map

Table 7. Distance to rivers and streams is suitable for Southern Leyte as depicted in the map in Fig. 6. Results have revealed a high distance to streams with 24.14% or 40648.40 ha. of the total land area, indicating high potential for agriculture associated with lower flooding risks and more land suitability for permanent crops, implying less prone to shifting. However, this has also had negative implications as it may require an irrigation system, increasing farm costs and dependency on rainfall, particularly in areas in Southern Leyte. On the other hand, 10.72% or 49816.81 ha. is classified as very high distance, indicating potential severe scarcity regarding water needs wherein water becomes the primary constraint in agricultural production. With no nearby rivers and streams, agricultural production increases costs associated with transporting water for irrigation or establishing appropriate farm water support and related infrastructure. Generally, agricultural production is challenging in some identified areas, with these areas relying on artificial water sources and careful soil and water management. However, these are advantageous in terms of flood risks and stability. This also highlights some areas for adjustments, particularly in water needs as without any nearby water sources, these may include installation of water conservation-related support infrastructure like rainwater harvesting, soil moisture management like terracing and

contouring, managing water flow and reducing runoff, allowing efficient water infiltration and climate adaptation strategies creating favorable microclimate in agricultural fields aimed at reducing evaporation and crop protection. According to Sabljic et al. (2024) that areas in close proximity to rivers may be more financially and economically feasible and more suitable for agriculture as it is simpler establish infrastructure like irrigation as compared to those of more distant areas.

Table 7: Distance to rivers and stream suitability classification

Suitability ID	Road Buffer	Suitability Classification	Area (ha)	%
5	0 - 500	Very High	49816.81	10.72
4	500 - 1000	High	40648.40	24.14
3	1000 - 1500	Moderate	29932.28	17.78
2	1500 - 2000	Low	19908.19	11.82
1	>2000	Very Low	28078.72	16.68
	Total		**168384**	**100.00**

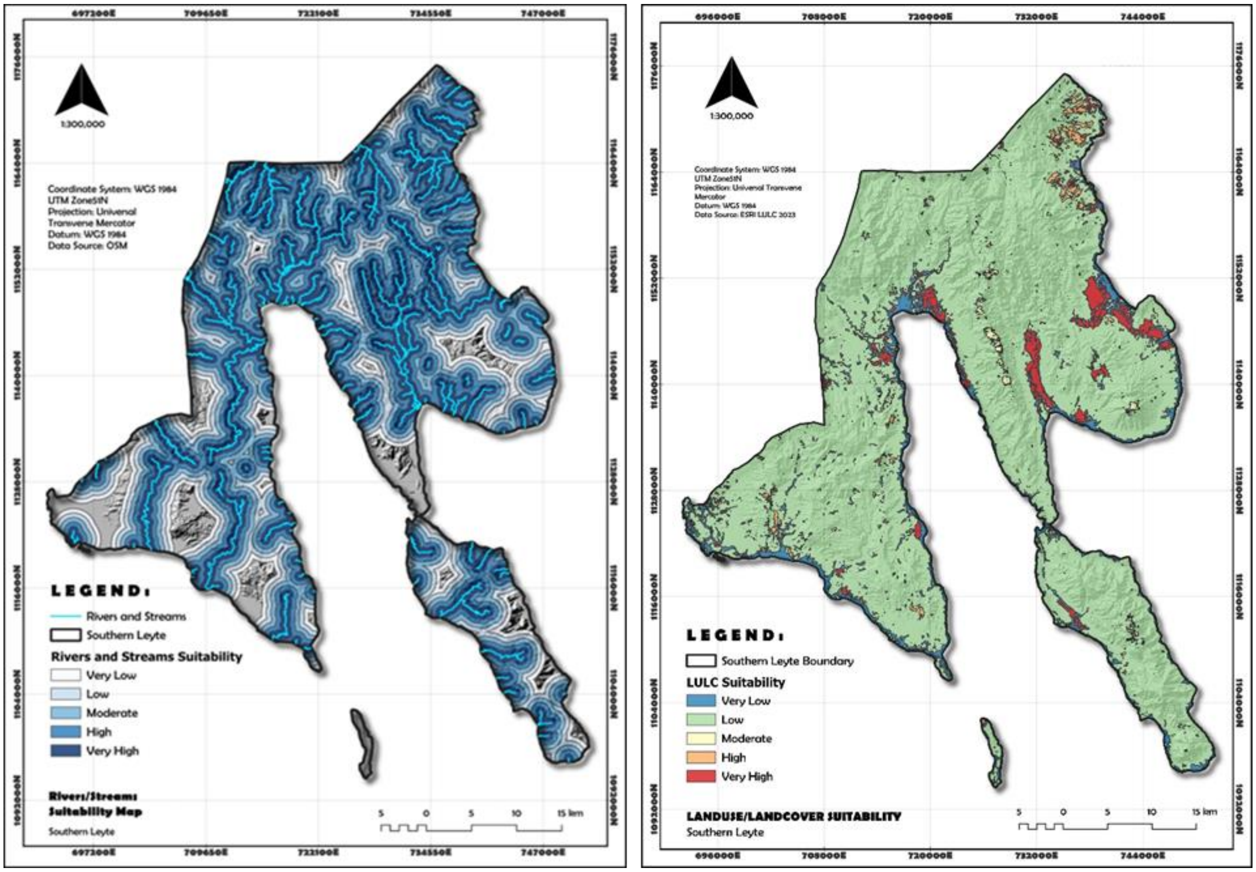

Figure 6: Distance to rivers and streams and land use land cover suitability map

Presented in Table 8 is the suitability of land use and land cover as shown in the map in Fig. 6. Data has shown that 88.96% of the total land area is classified as forest or barren, accounting for the 149,786.60-ha considered highly suitable. This indicates that forests and barren lands have potential for agriculture as forests may often have fertile soil due to high organic matter content and sufficient moisture. Although barren lands are idle, appropriate soil intervention can become productive, entailing investment in amendments, and its conversion to agriculture may not displace the existing ecosystems. On the other hand, agricultural land accounts for 2.95% or 4,968.97 ha of the total land area, which is described as very highly suitable. This implies that the area has fertile soil rich with OM and other nutrients, receiving adequate rainfall, access to irrigation, and flat to gently sloping terrain, which is ideal for agricultural productivity. However, it may face some challenges, like soil degradation associated with fertility loss, climate change, weather extremes, and urbanization. Proper soil conservation and health improvement, water management and conservation, climate adaptation strategies, and sustainable pest and disease control are crucial for sustained agricultural productivity amidst threats from external factors. Results from the study of (Gui Jin, 2015) have highlighted that land use changes had great impact on agricultural productivity involving analysis of on the impacts of land use changes.

Table 8: Land use and land cover suitability classification

Suitability ID	LULC Class	Suitability Classification	Area (ha)	Percentage
1	Built-up	Very Low	9799.36	5.82
2	Water bodies	Low	2805.19	1.67
3	Rangeland	Moderate	1023.42	0.61
4	Open/Barren	High	149786.60	88.96
4	Forest			
5	Agriculture	Very High	4968.97	2.95
	Total		168384	100.00

Presented in Table 9 is the data of temperature suitability as reflected in the map in Fig. 7. Optimum temperature ranges for crops have specific temperature requirements for germination, growth, and yield. Results have shown the highest temperature range so of 54°C – 58°C covering 63.83% or 107,471.29 ha of the total land area described as moderately suitable for agriculture, indicating severe heat stress on crops, extreme soil degradation, water scarcity, irrigation challenges, and economic and food security impact. Temperature variability may cause potential stress to plants associated with plant-water stress, drought-intolerant crops, and potential excess salts in soils linked to high-rate evaporation rates, leaving behind salt deposits and making lands unsuitable for farming. On the other hand, 1.35% of the area is considered very low suitability with temperature ranges >62°C which accounts for 2,274.64 ha of the total land area, indicating extreme heat beyond normal limits, which may potentially cease photosynthetic activity and leading to immediate death to crops and other vegetation. Although vegetation may adapt to this kind of temperature classification, these conditions may restrict crops' growth and survival due to a higher transpiration rate, leaving plants dehydrated and wilted with lower chances of survival and productivity. According to Bonfante et al. (2015) the production potential is dependent on the radiation received and temperature variations affecting crops crop and influencing the length of the growing season and establishment of different phenological stages.

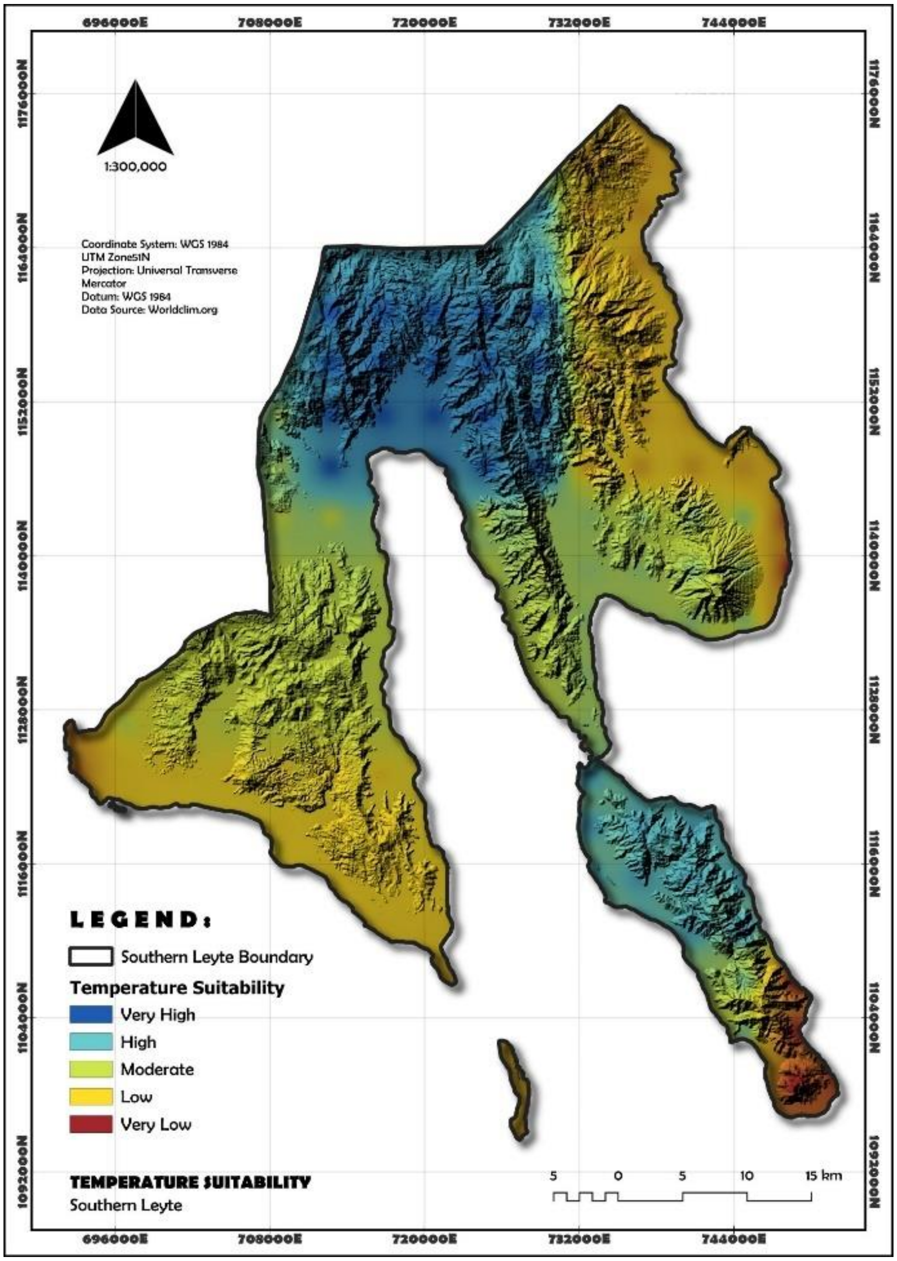

Figure 7: Temperature suitability map

Table 9: Temperature suitability classification

Suitability ID	Temperature Range	Suitability Classification	Area (ha)	%
5	<50°C	Very High	2744.01	1.63
4	50°C – 54°C	High	24381.58	14.48
3	54°C – 58°C	Moderate	107471.29	63.83
2	58°C – 62°C	Low	31511.97	18.71
1	>62°C	Very Low	2274.64	1.35
	Total		**168384**	**100.00**

Presented in Table 10 is the agricultural suitability of Southern Leyte Philippines, as shown in the map in Fig. 8. This evaluates nine parameters, including geomorphology and hydrology, to identify areas suitable for agriculture. Results have revealed that most of the area is categorized as very low suitability, which covers 52.59% or 88,559.56 ha, indicating poor soil quality, inadequate water supply, and steeper slopes. This conforms with most soil types, considered less suitable due to their classification, waterlogging, and low water retention. Its topographic conditions with mountainous and rugged terrain make it unfeasible for agriculture without significant intervention. According to Irawan et al. (2022) that the land potential is associated with its geomorphology and the underlying physical characteristics and processes. Aside from that, insufficient water supply and extreme weather conditions have been considered critical factors contributing to becoming agriculturally feasible. The area is considered less likely to accumulate water due to a total wetness index indicating a lower water retention rate associated with soil type. Also, extreme weather conditions are associated with temperature extremes considered moderately suitable, indicating temperatures beyond normal have high rates of evaporation, making the soil less suitable. This was further escalated by its high distance to rivers and streams, making the majority of the area at high risk of drought as rainfall may be insufficient and irregular, making crops rainfed depend on and making agriculture areas prone to erosion and less fertile due to lack of moisture retention and heat reducing the overall profitability of agricultural ventures. On the other hand, only 2.04% of accounts of the 3,436.18-ha are categorized as very high suitability, indicating optimal soil quality with a good balance of nutrients and fertile, sufficient water availability, ideal climate conditions with consistent rainfall, and minimal risks of extreme weather events. These areas are classified as low risk to natural disasters and less prone to flooding, droughts, and other natural events that could harm crops and reduce yield. Although this indicates a smaller fraction of the total area, suggesting only a limited area is naturally suitable for intensive agriculture, this also accounts for some areas that may be categorized as moderate suitability, and very high suitability provides conditions that maximize crop yields and minimize the need for interventions like irrigation and soil amendments. According to Zhang et al. (2023) that specific meteorological factors agricultural production and the assessment of major meteorological factors are crucial in assisting decision makers and growers in adapting to the changing climate by minimizing the agricultural production risks.

Table 10: Agricultural suitability model

Suitability ID	Suitability Classification	Area (ha)	%
1	Very Low	88559.56	52.59
2	Low	29350.74	17.43
3	Moderate	28448.95	16.89
4	High	18587.06	11.03
5	Very High	3437.18	2.04
	Total	168383.51	100

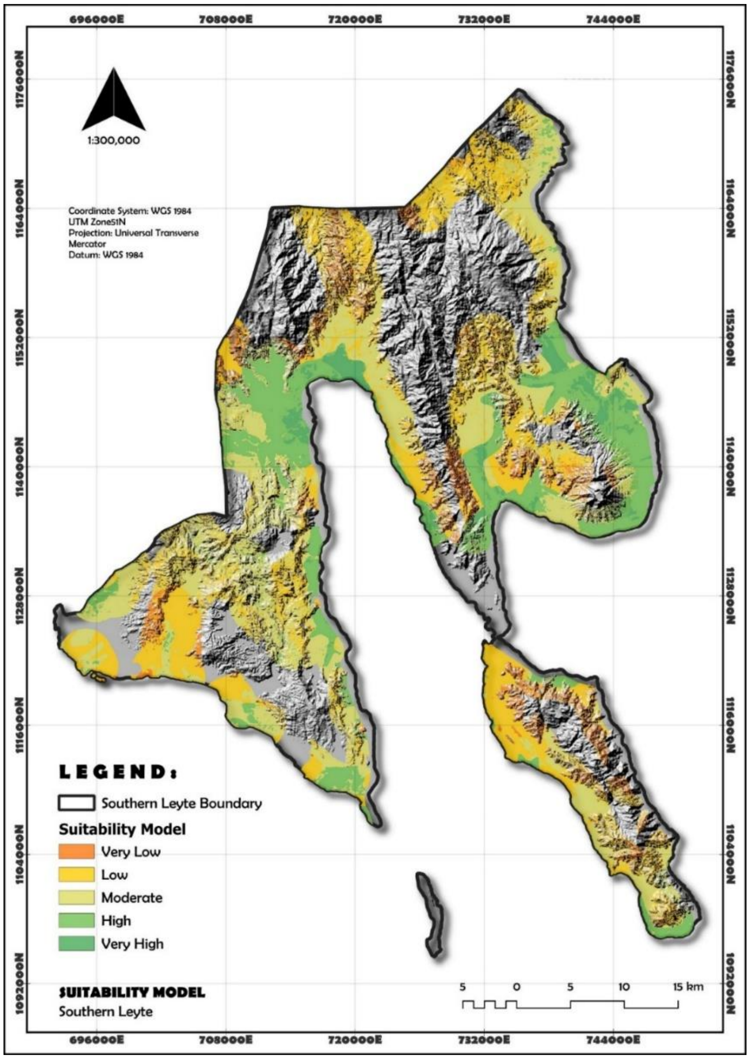

Figure 8: Agricultural suitability map in Southern Leyte Philippines

CONCLUSION

This study aimed to determine the agricultural suitability of Southern Leyte, Philippines, utilizing GIS and remote sensing approaches based on geomorphological and hydrological parameters. Data have shown that 37.94% or 63,883.54 ha of the study area is described as very high suitability with slope classification ranging from <3% classified as level to nearly level. Regarding TWI, it was classified as low suitability, showing that 41.85% of the area with 70,463.14 ha is considered moderately low moisture accumulation. It shows moderate drought conditions with a small but noticeable amount of moisture accumulation. For rainfall, 42.27% or 71,183.12 ha receive moderate rainfall ranging from 3,370-3,570 mm of annual rainfall, indicating moderate suitability reflecting average precipitation levels in the region with neither excessively dry nor excessively wet. In terms of elevation ranges, it reflects very high suitability with an elevation of <200 masl, indicative of a low-lying area that covers 46.21% or 77,804.28 ha, reflecting ideal for crop production also accompanied with risks of potential flooding incidence but can be alleviated with proper flood control measures and installation of flood control related infrastructure. The soil classification was described as very low suitability, covering 51.89% of the study area, accounting for 87,366.09 ha belonging to the group of hydrosol, beach sand, rough stony land, and rough mountainous land, indicative of poor agricultural suitability. The road buffers fall to 2,000 km. They are considered highly suitable, covering 32.88% or 55,370.12 ha of the total land area and indicative of distance from road networks, suggesting lesser exposure to dust and other air pollution from the built environment. Its distance to rivers and streams is described as very high, which accounts for 24.14% with 40,648.40 ha of the total land area, indicative of lower water accessibility and reduced agricultural suitability. The land uses land cover suitability classified as open/barren and forest, which covers 88.98% or 149,786.60 ha, described as high suitability, and the least was agricultural land, accounting for 2.95% with 4,968.97 ha categorized as very high an indicating majority of land is suitable for agricultural purposes but not necessarily for agriculture due to its current land use classification. For temperature variation, it recorded moderate suitability for large areas, accounting for 63.83% or 107,471.29 ha, indicating temperature beyond normal, making areas less suitable for crop production. The agricultural suitability of Southern Leyte is very low based on its geomorphology and hydrology, covering 52.59% or 88,559.56 ha, indicating poor soil quality, inadequate water supply, extreme weather conditions, and topographic characteristics. This implies significant farming limitations requiring substantial investment in infrastructure and rigorous land management strategies to increase productivity potential.

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