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GEOSPATIAL ANALYSIS AND MAPPING OF THE HABITAT SUITABILITY OF *AQUILARIA* SPECIES IN MT. HAMIGUITAN RANGE WILDLIFE SANCTUARY, DAVAO ORIENTAL, PHILIPPINES

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Abstract

This study aimed to determine the habitat suitability of Agarwood species in Mt. Hamiguitan Range in different strata employing Geographic Information System (GIS) and Remote Sensing (RS) techniques. More research is needed on its spatial distribution and habitat suitability, particularly in the Davao Region. A stratified sampling is employed for two agarwood species, *Aquilaria cumingiana* (Decne.) Ridley and *Aquilaria malaccensis* Lamk were identified. Assessment of agarwood abundance across elevation ranges revealed varying levels, with precipitation and elevation emerging as influential factors and utilizing Multi-Criteria Decision Analysis (MCDA) with Analytical Hierarchy Process (AHP). Results have revealed two (2) species of Agarwood with varied characteristics. The species distribution of Agarwood has been identified and distributed in sampling areas ranging from 1,171 to 1,480 meters above sea level, classified as very high abundance. Regarding suitability layers, precipitation ranges are classified as low, receiving rainfall of 5,715 hectares, moderate elevation with 9,540 hectares with Malalag loam as the dominant soil type with 13,376 hectares. Slope aspect classified as very high with 6,911.71 hectares, in terms of vegetation cover, MHRWS is classified as high at 10,400.97 hectares, with the distance to the stream categorized as very high at 5,226.18 hectares. The AHP identified precipitation as the most influential factor in determining the habitat suitability of Agarwood. Habitat suitability shows moderate suitability with a total land area of 7,199.09 with overall accuracy of the habitat suitability model of 94.11%.

Keywords: Analytical Hierarchy Process, Habitat Suitability, GIS, Davao Oriental, Philippines.

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INTRODUCTION

The wood industry in the Philippines has been facing significant challenges for decades due to overexploitation, unsustainable practices, and shifting economic priorities. To mitigate this decline, the promotion of non-wood forest products (NWFPs) has become a strategic alternative to revitalize the forestry sector and support sustainable livelihoods. Among these NWFPs, agarwood — locally known as Lapnisan (DENR 2021) — stands out as a highly valuable, aromatic, resin-impregnated wood derived from infected trees of the *Aquilaria* and *Gyrinops* genera (DENR 2021). Key species include *Aquilaria cumingiana*, *A. malaccensis*, *A. crassna*, and *Gyrinops versteegii*, *G. caudata*, *G. ledermanii*, and *G. walla* (Tan et al. 2019, CITES 2022).

Agarwood is globally renowned for its use in perfumes, incense, traditional medicine, and spiritual rituals due to its rare and complex fragrance (Pearlin et al. 2019, Akter et al. 2013). These genera belong to the family Thymelaeaceae, with several species naturally occurring throughout the Philippines (Ceniza et al. 2021). According to the Ecosystems Research and Development Bureau of the Department of Environment and Natural Resources (ERDB-DENR 2022) in their published factsheet No.3 in September 2022, eight species of *Aquilaria* have been documented in the country, predominantly distributed across Mindanao, suggesting a regional concentration that warrants focused ecological attention.

Understanding the spatial distribution patterns of agarwood species is essential for effective conservation and sustainable management, as it informs ecological requirements, population dynamics, and threats (Hazarika et al. 2023). The Davao Region is recognized as a key hotspot for agarwood diversity due to its favorable tropical climate, rich biodiversity, and suitable edaphic and hydrological conditions (CITES 2022). However, limited research exists on the habitat suitability and distribution modeling of *Aquilaria* species in this region, which poses a challenge to establishing science-based conservation frameworks and managed production areas.

This study aims to assess the habitat suitability of *Aquilaria* species in Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS), Davao Oriental, Philippines. Specifically, it seeks 1) to identify *Aquilaria* species present in MHRWS, 2) to determine *Aquilaria* species abundance within the sanctuary, 3) to analyze *Aquilaria* individual contribution of selected environmental variables: rainfall, elevation, slope, soil type, vegetation cover, and distance to streams, 4) to generate a habitat suitability model for *Aquilaria* species in MHRWS using spatial analysis techniques.

MATERIALS AND METHODS

Design and procedure

This study used a quantitative, descriptive, non-experimental research design. It aimed to determine the *Aquilaria* species found in the Mt. Hamiguitan Range and Wildlife Sanctuary across a range of ecological types. This study will characterize and record the traits, actions, mindsets, people, or phenomena. In quantitative design, linkages, patterns, and trends within the population or sample are quantified using statistical analysis and numerical configurations. Moreover, this assesses the geospatial distribution of *Aquilaria* species on Mt. Hamiguitan Range Wildlife Sanctuary, combining statistical analysis and Geographic Information System (GIS)-based techniques to identify intricate linkages and impacts among variables (Denzin et al. 2017). Phase 1 of the process involved gathering data. IFSAR-DEM data with 10-meter accuracy were extracted from DENR XI. A raster layer from the Bureau of Soils and Water Management (BSWM) was utilized to analyze the geographical distribution of *Aquilaria* species to determine the type of soil. The percentage of vegetative cover and the distance to the stream were examined using the Normalized Difference Vegetative Index (NDVI). In addition, this makes use of a multi-spectral remote sensing data approach to identify vegetation, water bodies, vegetation index, and land cover categorization (Gandhi et al. 2015). The rainfall data used in this study were extracted from worldclim.org global data utilizing the historical average precipitation at a spatial resolution of 1 km^2. Phase 2 involves the reclassification process of various suitability layers classified into five categories based on the predetermined standards or threshold values. After the reclassification procedures, the assignment of weights among various environmental layers is done by applying multi-criteria decision-making-analytical (MCDA) employing the Analytical Hierarchy Process (AHP). The last phase of the study involves the utilization of weighted sum overlay analysis. The QGIS raster calculator tool was used to generate a habitat suitability map. The weighted sum overlay analysis integrates numerous raster layers by giving each raster layer a weight based on its relative value for the habitat suitability study of *Aquilaria* species in Mt. Hamiguitan Range Wildlife Sanctuary.

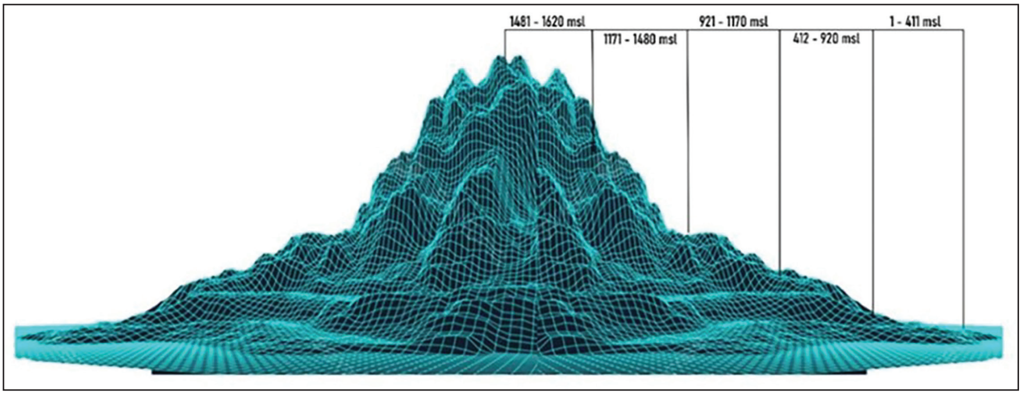

Figure 1. Wire Mesh Model representing elevation for stratified sampling.

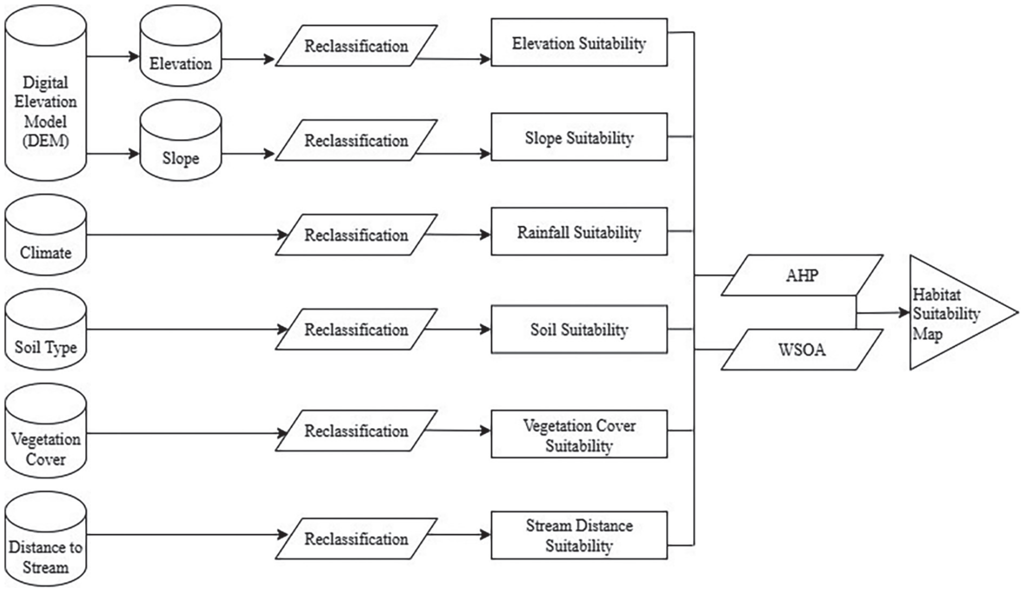

Figure 2. Study framework.

The Semi-Automatic Classification Plugin (SCP) plugin was used to streamline further and consolidate the habitat suitability map that was created using the raster calculator tool that is embedded in QGIS. This allows for efficiency and clarity in the interpretation of complex spatial data. The study applies a methodical strategy to examining the distribution and abundance of *Aquilaria* species in the different ecological zones and elevation ranges of Mt. Hamiguitan Range Wildlife Sanctuary using stratified sampling. This ensures that a representative sample was taken from each stratum, minimizing bias and guaranteeing an accurate representation of the quantity and existence of *Aquilaria* species in Mt. Hamiguitan Range Wildlife Sanctuary. Additionally, vegetation cover within each ecological staircase was observed, and streams, creeks, and other bodies of water were geotagged to determine the distance to *Aquilaria* species sightings.

The study area

The Mount Hamiguitan Range Wildlife Sanctuary (MHRWS) is a critical biodiversity hotspot located in the province of Davao Oriental in southeastern Mindanao, Philippines. It spans approximately 16,837 hectares, traversing the Municipalities of San Isidro and Governor Generoso, as well as the City of Mati, with an elevation gradient ranging from 170 to 1,637 meters above sea level (UNESCO 2014). As part of the Eastern Mindanao Biodiversity Corridor, the sanctuary serves as a vital refuge for a wide array of endemic and threatened flora and fauna, many of which are found nowhere else on Earth (Fernando et al. 2008). The area hosts diverse habitat types, including montane and mossy forests, ultramafic outcrops, and pygmy forests on thin soils (Gruezo et al. 2008). MHRWS is UNESCO World Heritage Site in 2014.

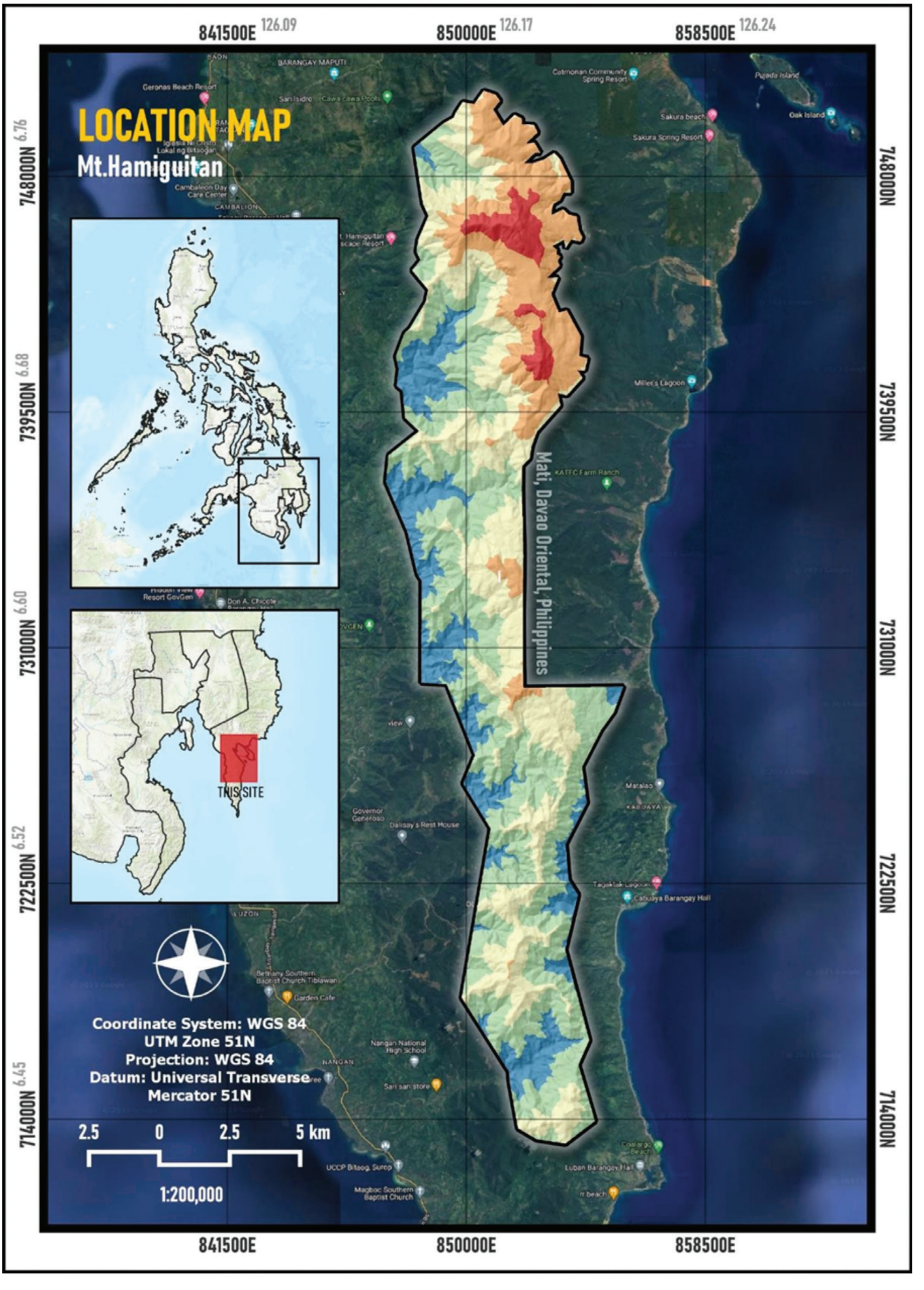

Figure 3. Map showing the location of the Mt. Hamiguitan Range Wildlife sanctuary.

RESULTS AND DISCUSSION

Taxonomic identification of *Aquilaria sp.*

The projected total land area of Mt. Hamiguitan Range Wildlife Sanctuary is 100 hectares, divided among five (5) different environmental system types. Agarwood is a highly valued and precious resinous wood with a peculiar scent. Locals in Davao Oriental refer to it as the "wood of gods." It is principally generated by certain species of the Thymeleaceae family, which is endemic to several Asian locations, including Region XI, the Philippines, and the Gyrinops tree genus. Key Informant Interviews (KII) and stratified sampling revealed two Agarwood species- *Aquilaria cumingiana* (Decne.) Ridley and *A. malaccensis* Lamk. Presented in Figure 3 are the results of the taxonomic identification, which shows that the leaves of *A. cumingiana* were alternate and simple in terms of leaf attachments. Also, variations in midrib width, marginal vein width, and the blade class among the 30-leaf specimen were assessed. Trichomes in the laminar area were observed but still investigated for solid evidence. The laminar shape was lanceolate, and the laminar size varied from 754mm to 5600 mm. The leaves show symmetrical, glabrous, cuneate, entire, and acute both in leaf shape, base angle, apex shape, and apex angle. The leaf texture was smooth and shiny, light green in color, untoothed, and had no lobation. The leaf venation was pinnate, weak in primary vein size, regular polygonal reticulate, and the vein spacing was increasing toward the base which is consistent with characteristics described in species reviews across Southeast Asia (Naziz et al. 2019).

Figure 4. Studied leaves with leaf composition (A), leaf shape (B), leaf base apex (C), leaf base (D), leaf margin and leaf surface coverings (E) of *Aquilaria cumingiana*. Image courtesy: Rhea Lou Rivera.

Abundance and occurrence of *Aquilaria sp.* in Mt.Hamiguitan Range Wildlife Sanctuary

In determining the abundance and presence of *Aquilaria sp*., results shown in Table 1 revealed that *Aquilaria sp.* has been found across various sample sizes. The Mt. Hamiguitan range elevation ranges from 1 to 1,620 mean above sea level. Additionally, *Aquilaria* sp. was found in four (4) of the five (5) elevation ranges. Moreover, this encompasses 61% or 38 out of 62 observed *Aquilaria sp.* distributed across strata, indicating elevation ranges of 1,171 - 1,480 considered to have extremely high abundance. This was followed by the elevation range of 921 - 1,170, which is characterized as having a high abundance that covers 19% or 12 out of 62 species observed in the study area. Moreover, the elevation range of 1 - 411, which is characterized as having a moderate abundance, comprises 13% or 8 out of 62 species observed, and the elevation range of 412 - 920, which has the least amount of *Aquilaria sp.* observed in the study area with 7% or 4 out of 62. However, species of *Aquilaria* have not been found at elevation ranges between 1,481 and 1,620 m.a.s.l. The diversity of historical events, the evolutionary process, the intricate dynamics of ecosystems, and many environmental conditions may all be related to species richness in different areas. Moreover, *Aquilaria sp.* presence and abundance along various elevation gradients are thought to be influenced by several factors, including climate, geography, biological interactions, habitat availability and fragmentation, human activity, and evolutionary processes. Furthermore, the diversity of species distribution suggests that different species inhabit various habitats and geographic regions, and they might differ significantly in terms of the stratification of forests and ecosystems. This patter highlights the significance of elevation in determining *Aquilaria* distribution, echoing findings in the East Himalayas where mid-elevation habitats foster optimal conditions for *A. malaccensis* due to balanced moisture, temperature, and canopy cover (Thapa et al. 2023).

Table 1. The species abundance in Mt. Hamiguitan Range Wildlife sanctuary.

Sampling Range (m.a.s.l.)	Presence	Abundance class	Abundance value
1 – 411	Yes	Moderate	8
412 – 920	Yes	Low	4
921 – 1170	Yes	High	12
1171 – 1480	Yes	Very high	38
1481 – 1620	No	Very low	0

Suitability layers

Precipitation

Table 2 shows the study area's 10-year precipitation suitability. Data have revealed that the maximum reported precipitation values vary from 2,301 to 2,875 mm, while the lowest values are between 1 and 576 mm. Conversely, the most significant amount of precipitation ever recorded falls across 73 ha. of land or 46% of the whole land area, and 452 has the least amount of precipitation, approximately 2.90% of the land area on its whole. Numerous elements, including temperature, humidity, and atmospheric pressure, have been identified as contributing to the variability of precipitation in different locations concerning coverage. Studies from Indonesia have similarly emphasized how climate-driven reductions in rainfall could shift habitat suitability for *Aquilaria* species (Ramdani et al. 2021).

Table 2. Average ten-year annual precipitation ranges of Mt. Hamiguitan Range Wildlife sanctuary.

Values	Classification	Precipitation ranges (mm)	Area (ha)
1	Very low	1 - 576	452.00
2	Low	577 - 1151	5715.00
3	Moderate	1152 - 1725	5279.00
4	High	1726 - 2300	4041.00
5	Very high	2301 - 2875	73.00
Grand total			15,544.00

Elevation

The Mt. Hamiguitan Range Wildlife Sanctuary has height ranges from 1 to 1620 mean above sea level, which are further divided into extremely low and very high elevations. With 9,540 ha considered moderate elevation, it has the most land coverage based on the data, which comprises 61.37% of the entire land area within the Mt. Hamiguitan Range Wildlife Sanctuary, with 47 being the lowest elevation, approximately one-third of the entire land area. These zones typically offer favorable microclimate conditions, as supported by global models of agarwood habitat suitability (Thapa et al. 2023). Understanding elevation is essential to comprehending the patterns of species distribution. For instance, high elevation modifies the structure and content of habitats, which can result in variations in habitat compatibility. Elevation also affects patterns of precipitation.

Table 3. The elevation ranges of Mt. Hamiguitan Range Wildlife sanctuary.

Values	Classification	Elevation ranges (m.a.s.l.)	Area (ha)
1	Very low	1481 - 1620	47.00
2	Low	1 - 411	2510.00
3	Moderate	411 - 920	9540.00
4	High	921 - 1170	2279.00
5	Very high	1171 - 1480	1168.00
	Grand total		15,544.00

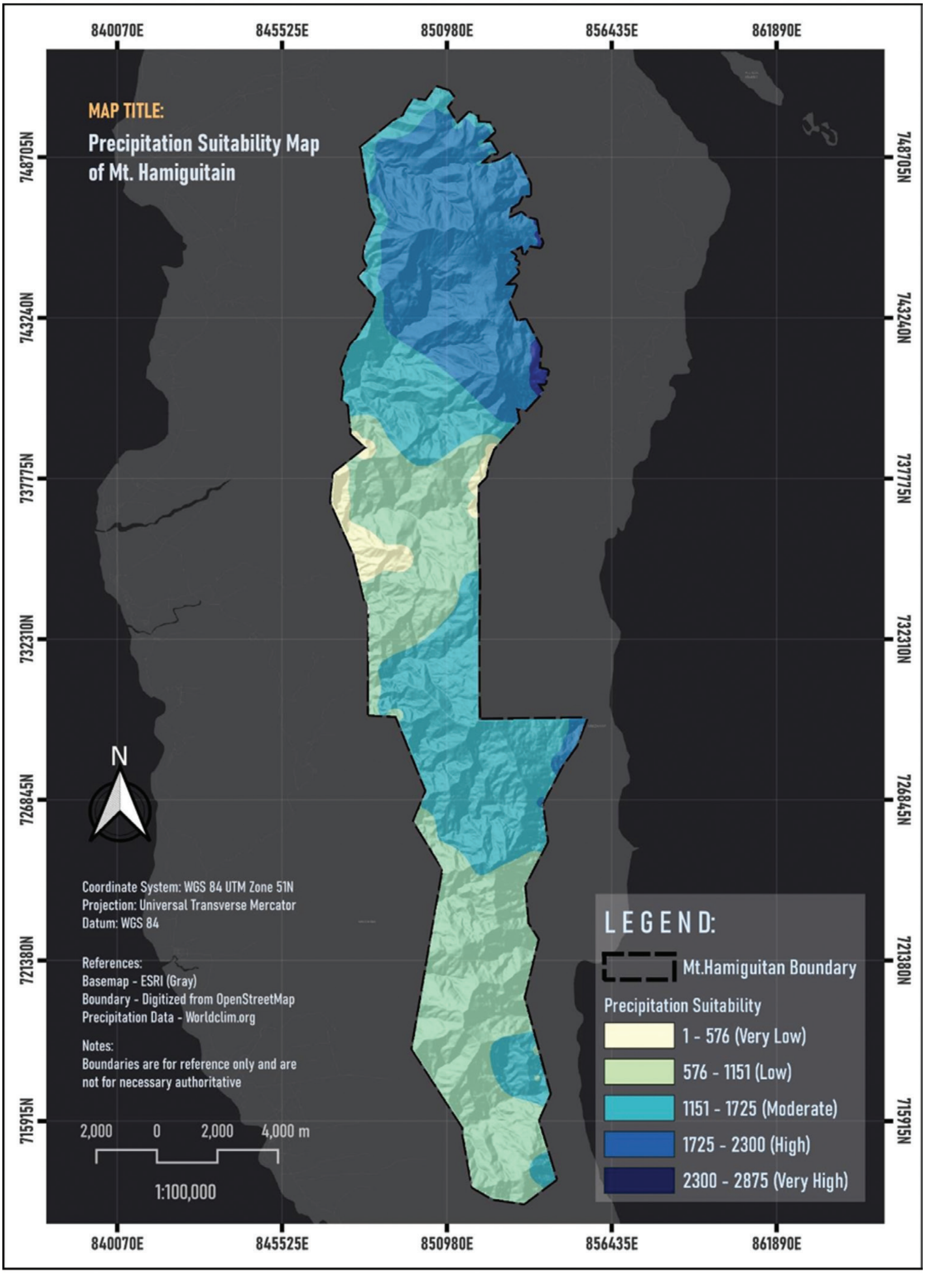

Figure 5. Map showing the precipitation suitability in Mt. Hamiguitan Range Wildlife sanctuary (MHRWS).

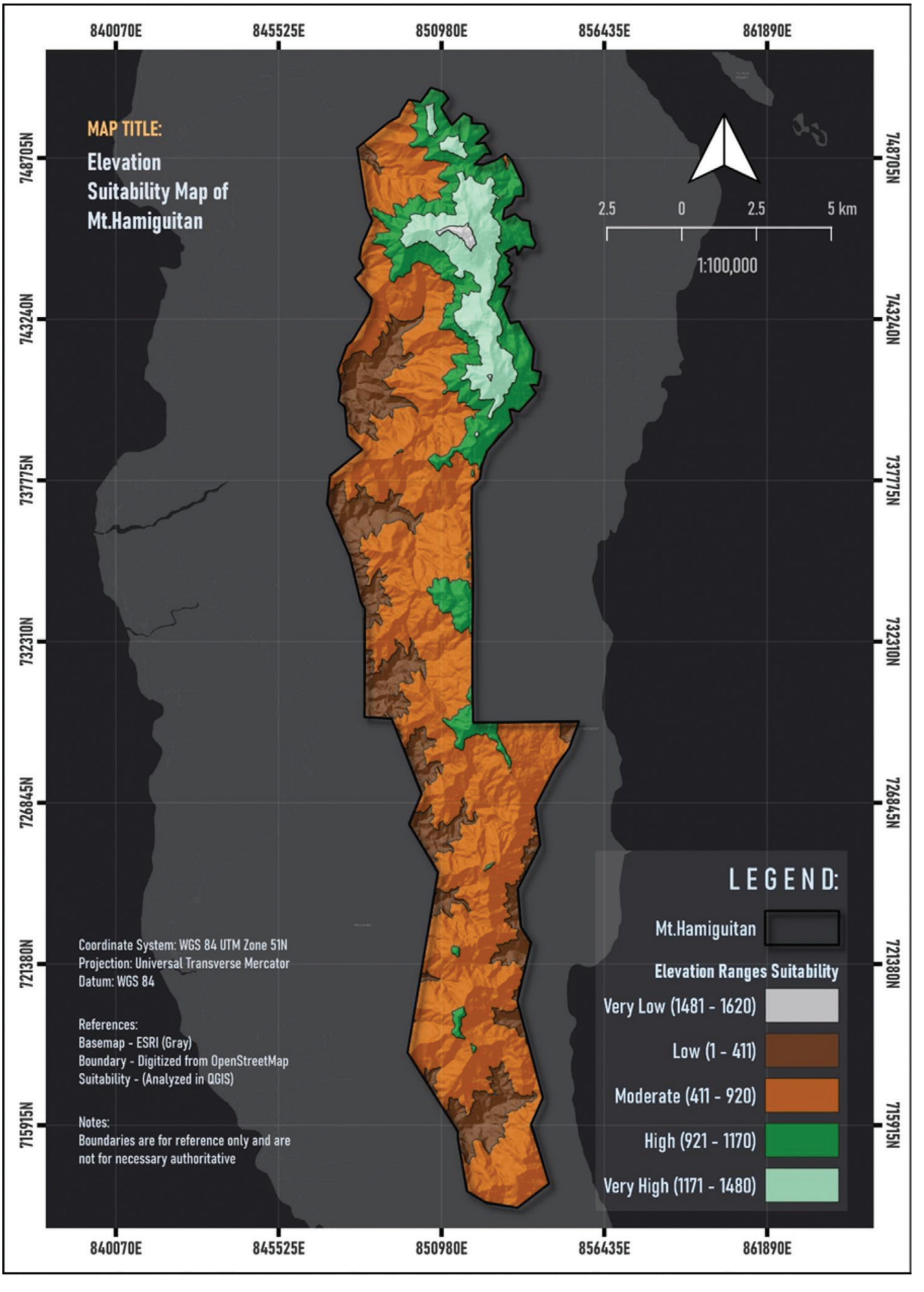

Figure 6. Map showing the elevation Range Suitability in Mt. Hamiguitan Range Wildlife sanctuary (MHRWS).

Soil type

Regarding soil composition, it is regarded as one of the primary factors that directly affect the accessibility of vital minerals and nutrients. The availability and amount of nutrients might differ throughout different types of soil. Table 5 indicates that 13,736 ha, or 88% of the soul type categorization, are classified as Malalag loam. Bolinao clay loam has the least amount of land, at 531 ha of the whole land area or, as seen in Figure 7, 3.41% of the study's overall land area. Loam soil is said to be the best kind of soil for supporting plant growth and development. Moreover, loam soil has good nutrient retention capacity due to its texture and is adaptable to a wide range of plant species. This findings aligns with other studies in Leyte, Philippines where loamy soil was found conducive to *Aquilaria* propagation (Ceniza et al. 2021).

Table 4. The soil type of Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS).

Values	Soil description	Classification	Area (ha)
2	Bolinao Clay	Low	550.00
3	Bolinao Clay Loam	Moderate	531.00
4	Hydrosol	High	732.00
5	Malalag Loam	Very high	13736.00
Grand total			15549.00

Slope aspect

The distribution of flora, soil properties, microclimatic conditions, and biological processes within a given landscape are all significantly shaped by the slope aspect. The data on the research area's slope aspect suitability is displayed in Table 6. It was discovered that the slope of Mt. Hamiguitan Range Wildlife Sanctuary ranges from 0 to 70. Alternatively, 6,911.71 hectares in total, or 45% of the entire land area, is deemed to have a moderately steep gradient, although steep terrain can hinder tree anchorage and seedlings establishment, the microclimate variation it provides supports niche diversity and may favor certain growth forms of *Aquilaria* (Tan et al. 2019). Alternatively, 54.69 hectares having the least amount classified as moderate, approximately 35% of the land area in all. Steeper slopes typically give plants less solid ground to grow on, which hinders production. On the other hand, slopes create microclimate due to variations in sun exposure and temperature. These microclimate variations can influence the types of vegetation that thrive in different strata.

Table 5. Slope aspect of Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS).

Values	Classification	Slope ranges	Area (ha)
1	Very high	56 - 70	6911.71
2	Very low	0 - 14	5131.22
3	High	43 - 56	2685.06
4	Low	15 - 28	642.47
5	Moderate	29 - 42	54.69
Grand total			15425.17

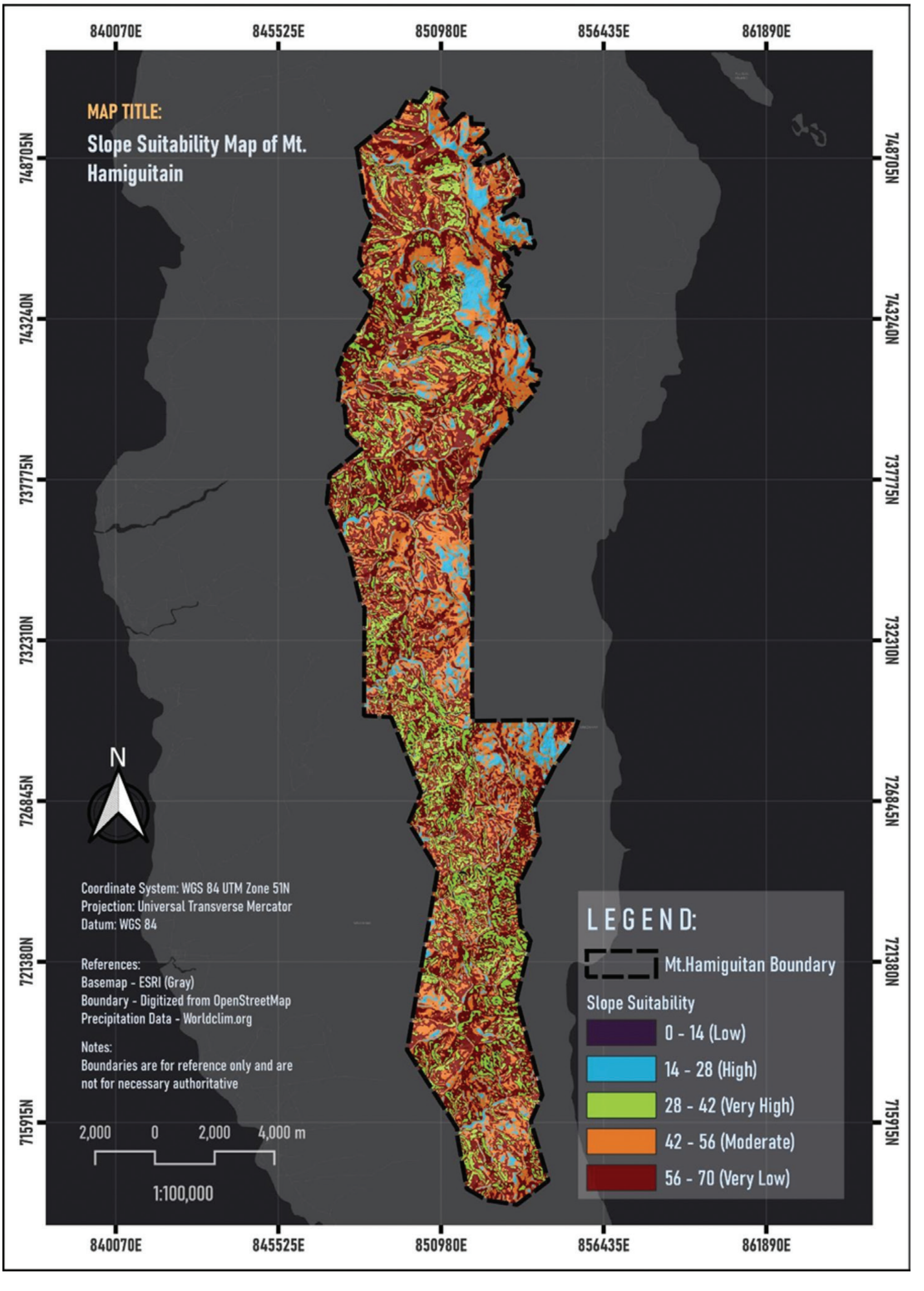

Figure 7. Map showing slope suitability in Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS).

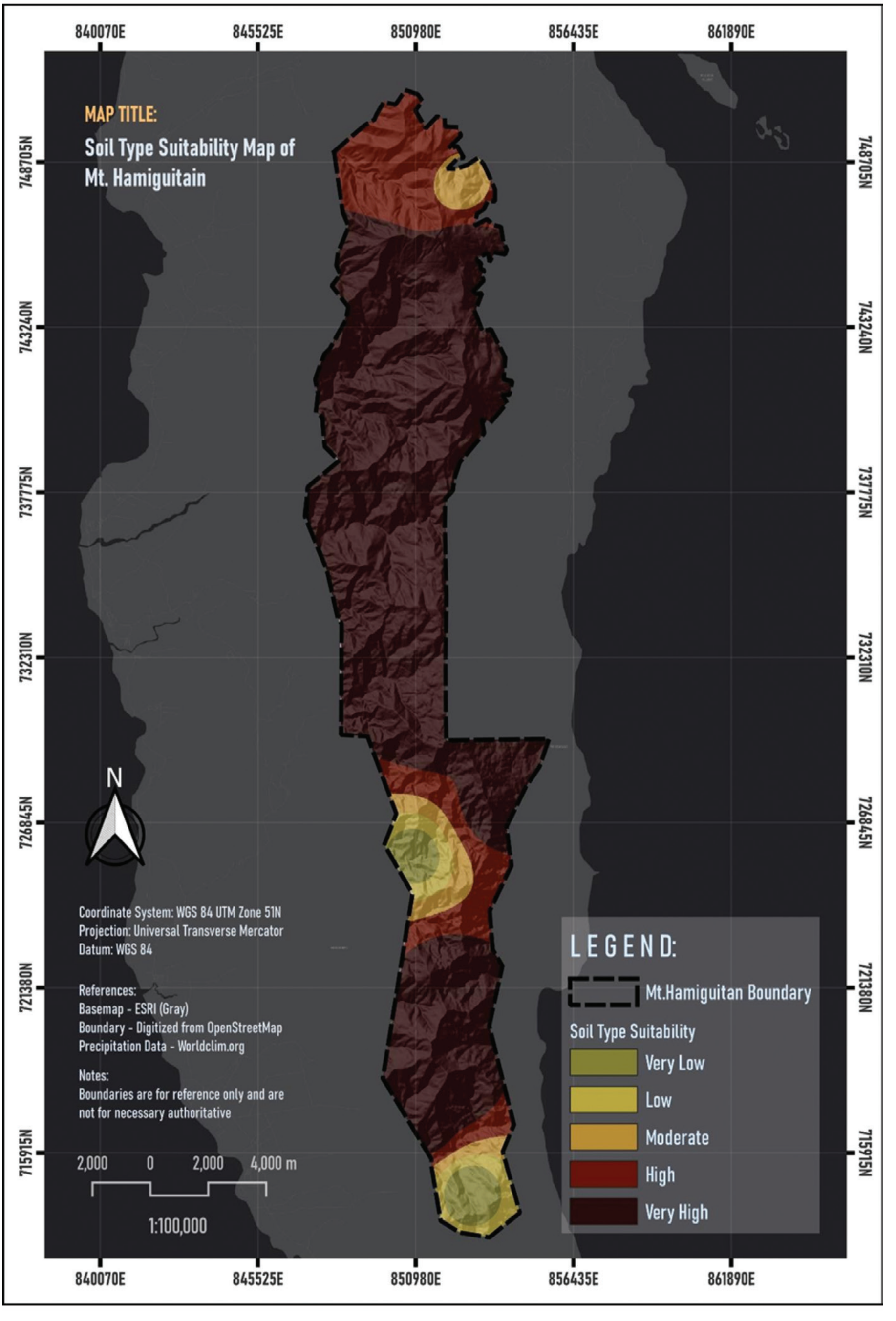

Figure 8. Map showing soil type suitability in Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS).

Vegetation cover

The structural complexity of the plant cover influences the appropriateness of the environment. Various plant types provide a range of microhabitats that provide niches for various species. Table 6 shows that the vegetation cover varies from 1 to 100%. According to this analysis, 10,400.97 ha, only 6.84, or 0.04%, of the total land area is classified as having low vegetation cover, whereas 66.8% is classified as having high vegetation cover, which varies from 60 to 80%. The microclimate of an ecosystem is influenced by the amount of vegetation present. As seen in Figure 6, it contains contribution data from communities and niches with higher humidity, moisture, and nutrient cycling, all of which enhance the appropriateness of the location for the species under investigation.

Table 6. Vegetation cover of Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS).

Values	Classification	Vegetation cover	Area (ha)
1	Very low	1% - 20%	6.84
2	Low	20% - 40%	129.55
3	Moderate	40% - 60%	4,823.79
4	High	60% - 80%	10,400.97
5	Very high	80% - 100%	202.08
Grand total			15,563.25

Distance to stream

Access to water is ensured by being close to streams, which is necessary for the survival of many species. When evaluating the overall viability of habitats, distance to streams is frequently considered in conjunction with other elements, including plant cover, terrain, climate, and human disturbances. The data on the research area's range of distances to streams is shown in Table 7, 5,226.18 hectares are displayed. 8.6%, or 1.340 hectares, of the total land area, is deemed to be at a very high distance from the stream and is seen as being closer to the stream. While proximity to stream is generally favorable for many forest tree species, this result suggests that *Aquilaria* may adapt to upland and mid-slope environments where competition and disturbances are lower, a finding corroborated by habitat suitability studies in similar tropical landscapes (Gandhi et al. 2015).

Table 7. Buffer distance to stream in Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS).

Values	Classification	Buffer distance	Area (ha)
1	Very low	1 - 100	1,340.04
2	Low	101 - 200	2,262.31
3	Moderate	201 - 300	3,019.73
4	High	301 - 400	3,695.50
5	Very high	401 - 500	5,226.18
Grand total			15,543.78

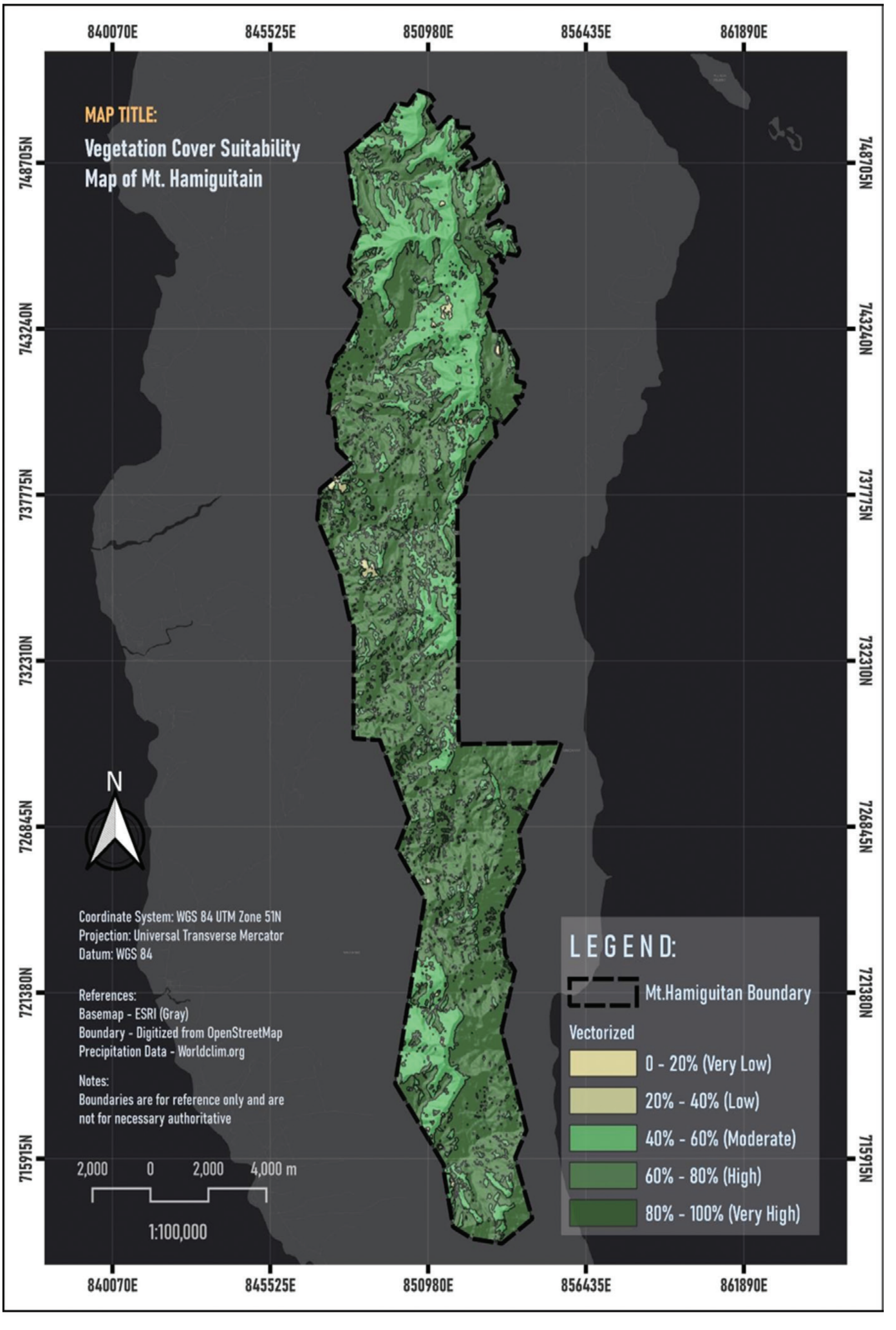

Figure 9. Map showing the vegetation cover suitability in Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS).

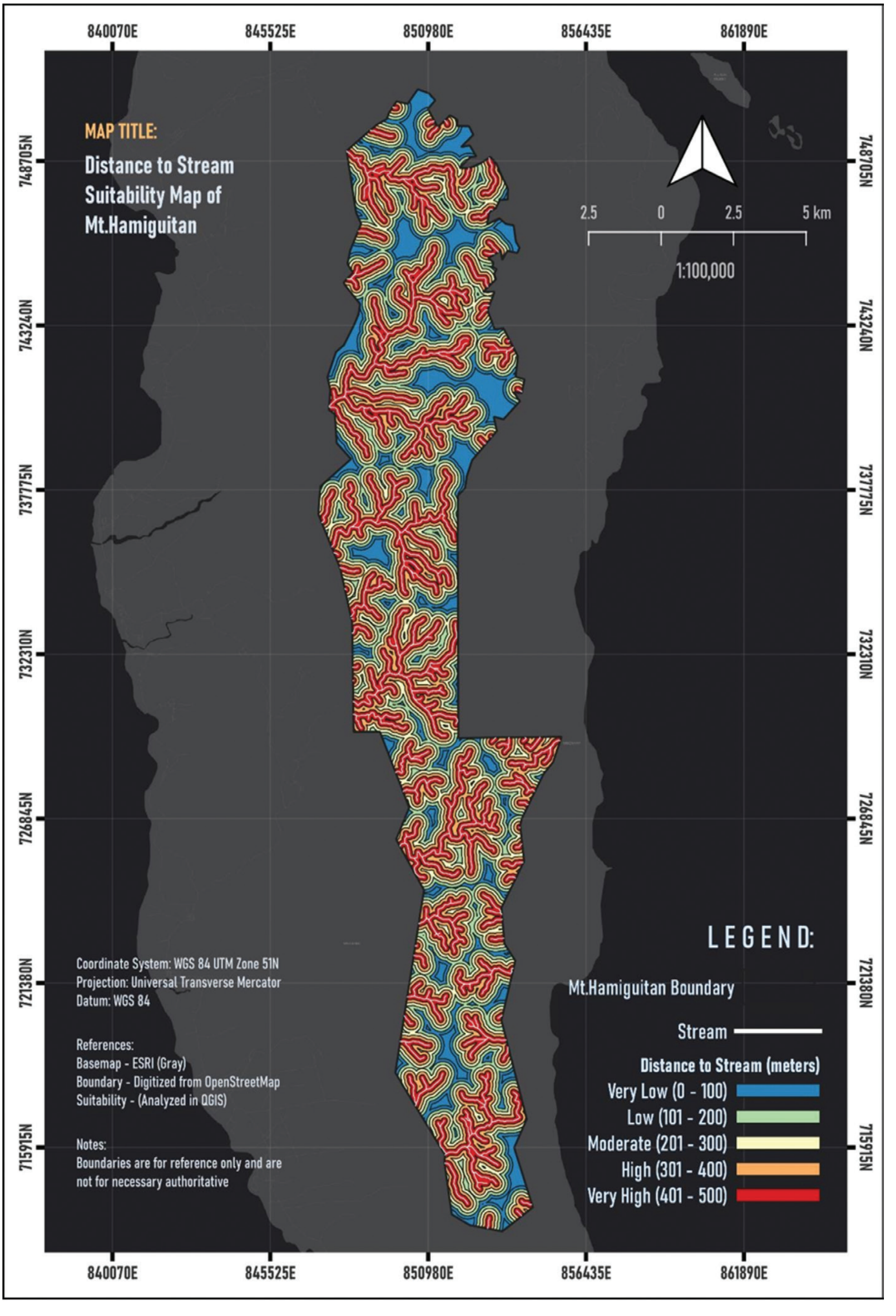

Figure 10. Map showing the distance to stream suitability in Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS).

Analytical hierarchy process (AHP)

As shown in Figure 8, the rankings and weights of factors about *Aquilaria sp.* habitat appropriateness in Mt. Hamiguitan Range Wildlife Sanctuary have been determined using the Analytical Hierarchy Process (AHP). Using hierarchy criteria created by Thomas Saaty, a collection of options or variables are ranked and prioritized using this organized decision-making approach. The elements that can have a major impact on the appropriateness of the habitat and the dispersion of *Aquilaria sp.* in different ecological strata on a spatiotemporal scale are revealed through focus group discussions. The standardized matrix of parameter comparisons for habitat suitability is shown in Table 8. The percentile-based rankings and weights for habitat suitability are also displayed in Figure 7. In determining the overall influences of each suitable layer for of *Aquilaria sp.* inside the Mt. Hamiguitan Range Wildlife Sanctuary, six (6) factors were prioritized. According to data, precipitation is seen to be the most critical factor in determining whether a habitat is suitable (27%), followed by elevation (24%), soil type (21%), slope (19%), plant cover (6%), and distance to stream (3%). This suggests that an ecosystem's water supply is directly impacted by precipitation. Sustaining water supplies like rivers, lakes, and groundwater is critical for preserving a variety of ecosystems. This requires an adequate amount of precipitation. Furthermore, precipitation supports hydrological processes that are vital in determining the features of habitats, such as runoff, infiltration, and groundwater recharge. This indicates even more flexibility to a variety of environmental circumstances outside of the vicinity of a stream. Even in habitats further away from steams, the species may still be able to thrive and show adaptability to varying environmental circumstances. Rainfall or other alternate water sources might be the source of this resistance. It is crucial to keep in mind, too, that the least significant factor affecting habitat suitability might alter over time or in reaction to outside disturbances. The role that streams proximity has in determining habitat suitability may change due to changes in precipitation patterns, land use, and climate. The suitability of a habitat is evaluated to see if it aligns with an ecological niche. Assessing the degree to which an environment satisfies the ecological needs and preferences of species within a given geographic area is crucial.

Table 8. Standardized matrix of parameters for habitat suitability, where CI-Consistency Index, CR-Consistency Ratio.

Criteria	Precipitation	Elevation	Soil	Slope	Vegetation cover	Distance to stream	Wights (%)
Precipitation	0.23	0.23	0.23	0.23	0.33	0.35	27
Elevation	0.23	0.23	0.23	0.23	0.25	0.26	24
Soil Type	0.23	0.23	0.23	0.23	0.16	0.17	21
Slope	0.23	0.23	0.23	0.23	0.16	0.09	19
Vegetation cover	0.06	0.06	0.06	0.06	0.08	0.09	7
Distance to stream	0.03	0.03	0.03	0.03	0.01	0.04	3.0
						SUM	100
						CI	.08
						CR	.09

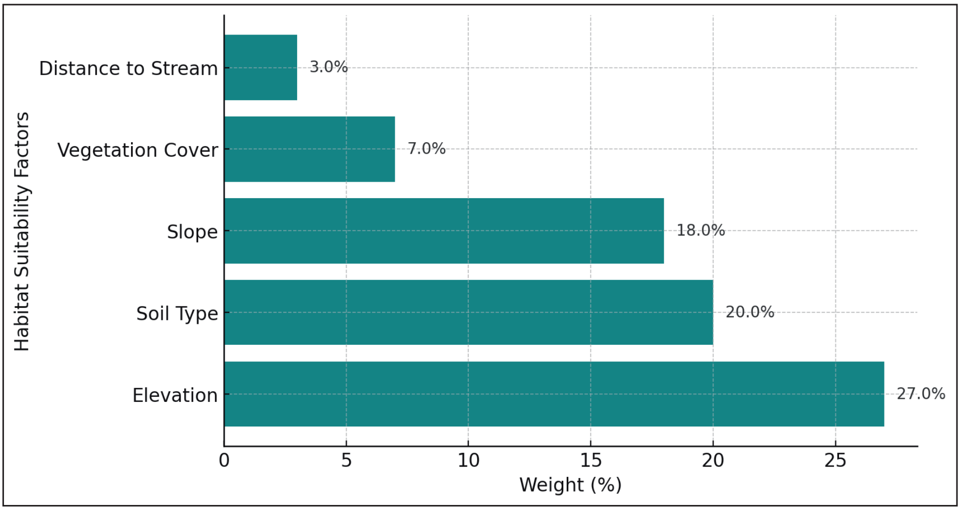

Figure 11. Percentile weight based on the standardized matrix of habitat suitability parameters.

Habitat suitability model

The general habitat suitability of *Aquilaria sp.* in the Mt. Hamiguitan Range Wildlife Sanctuary is shown in Table 9, which considers factors including precipitation, elevation, soil type, slope, plant cover, and distance to stream. The geospatial habitat suitability map of Mt. Hamiguitan Range Wildlife Sanctuary *Aquilaria sp.* is displayed in Figure 8. The categorization of moderate habitat suitability has the largest land coverage, with 7,199.99 hectares, according to the results, or 46.93% of the entire region, and its elevation is between moderate and high. There are 635.73 acres of the least-suited regions for *Aquilaria sp.*, about 4.14% of the land area. As the Mt. Hamiguitan Range Wildlife Sanctuary demonstrates, large hectares of habitat suitability suggest a healthy ecosystem. Healthy habitats also reveal favorable environmental conditions. Furthermore, a large area offers chances for sustainable development initiatives and conservation activities. Conversely, the smaller areas deemed less suitable as habitats show less fragmentation of the landscape and less disturbance of natural processes. Fewer appropriate environments can cause biodiversity loss, but it can also be a sign of increasing environmental conditions, recoveries, and successful environmental conservation initiatives. Human activities such as agricultural production and human encroachment into forested areas can also be linked to sources of landscape fragmentation that lead to a lower suitability categorization. Less habitat suitability inside the Mt. Hamiguitan Range Wildlife Sanctuary may have resulted from natural occurrences such as extended dry seasons, landslides, other extraordinary natural disasters, and human-induced unsustainable activities in forest regions.

Comparable spatial distribution models (SDMs) in India and Malaysia also report precipitation and mid-elevation as key determinants of *Aquilaria* habitat suitability (Ramdani et al. 2021, Thapa et al. 2023). The extensive moderately to highly suitable zones in MHRWS suggest robust habitat conditions and highlight conservation potential. With increasing threats to wild agarwood populations, such models serve as critical decision-making tools for localized conservation strategies, propagation programs, and restoration efforts.

Table 9. Habitat suitability of *Aquilaria* sp. in Mt. Hamiguitan range wildlife sanctuary.

Values	Suitability classification	Area (ha)
1	Very low	635.73
2	Low	2636.32
3	Moderate	7199.09
4	High	3728.63
5	Very high	1136.81
6	Pixel error	0.67
Grand total		15337.28

The spatial statistics and accuracy testing based on precipitation, elevation, soil type, slope, plant cover, and distance to stream data collected from Mt. Hamiguitan Range Wildlife Sanctuary are shown in Table 10 to assess the acceptability and correctness of the created map. The total accuracy of the other created habitat suitability map of *Aquilaria sp.* in Mt. Hamiguitan Range Wildlife Sanctuary is 94.11% based on the assigned rankings and weights of factors analyzed using AHP, according to accuracy testing using Semi-Automatic Classification Plugin (SCP). This accuracy rating indicates high-quality spatial data, including precise coordinates and attribute information. This further indicates that the model is predictive and that it can accurately identify data points with a high degree of precision or forecast outcomes. Furthermore, the underlying patterns and relationships in the data were correctly captured by this scenario.

Table 10. Area-based error matrix and accuracy testing of habitat suitability in Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS).

Classified	1	2	3	4	5	Area	WI
1	.29	0	0	0	0	500	.29
2	0	.17	0	0	0	300	.17
3	.05	0	.05	0	0	200	.11
4	0	0	0	.05	0	100	.05
5	0	0	0	0	.35	600	.35
Total	.35	.17	.05	.05	.35	1,700	1
Estimated area 600		300	100	100	600	1,700	0
Standard error	.05	0	.05	0	0	0	0
Overall accuracy (%) = 94.11							

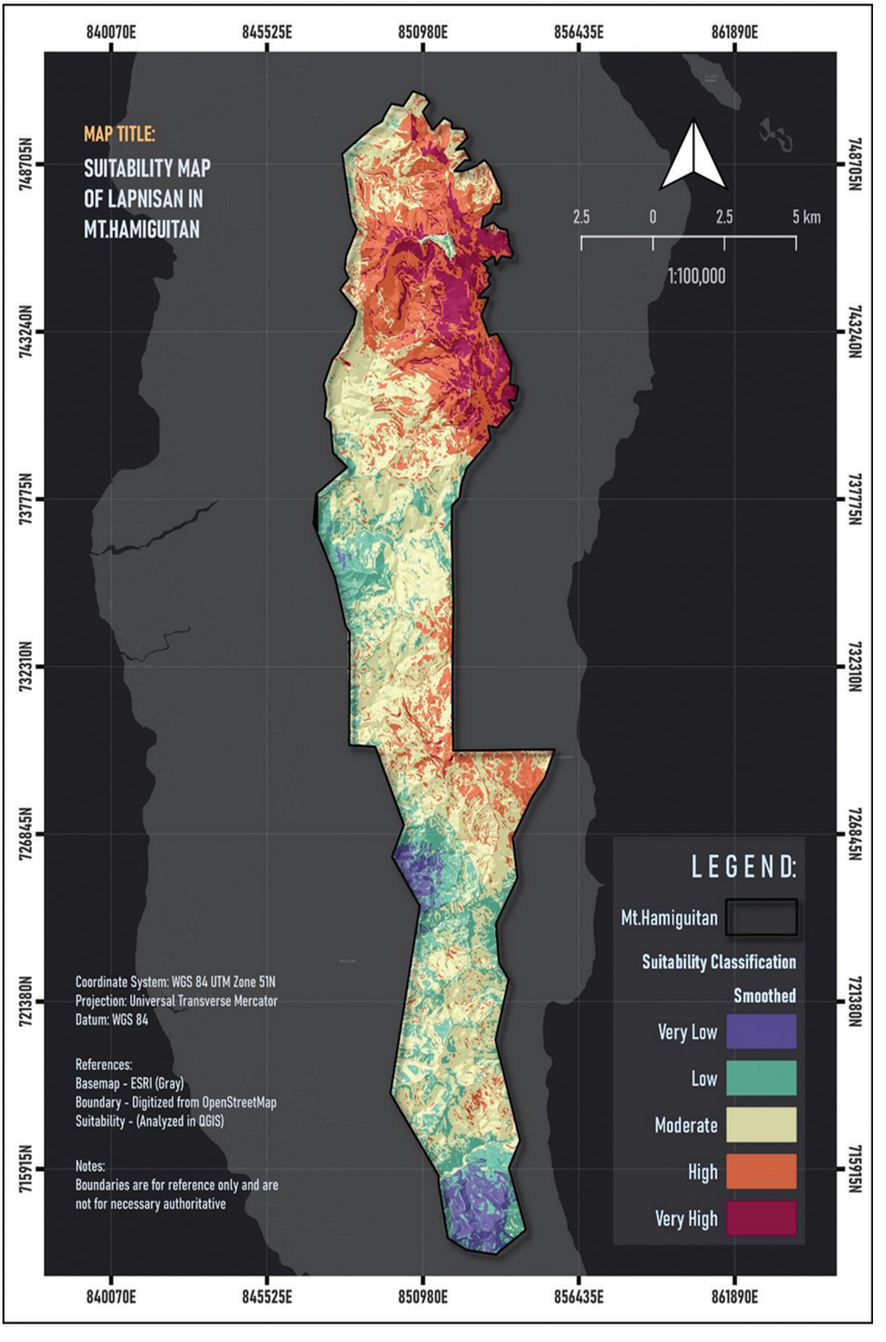

Figure 12. Habitat suitability map of *Aquilaria* species in Mt.Hamiguitan. Range Wildlife Sanctuary (MHRWS).

CONCLUSIONS

The study's findings revealed two (2) species of Agarwood spatially distributed at Mt. Hamiguitan Range Wildlife Sanctuary exhibiting unique and varied characteristics. In addition, the abundance and distribution of *Aquilaria sp.* are described as very high, with 61% of the 38 of 62 species distributed across different strata with a sampling range of 1,171-1,480 m.a.s.l. In terms of environmental layers, precipitation ranges are classified as low, receiving annual precipitation ranges of 577-1,151 mm, and the elevation is categorized as moderate with elevation ranges from 411-920 m.a.s.l. In terms of soil type, the most dominant is Malalag Loam, categorized as very, which comprises 13,736 ha of the total land area. The slope aspect is classified as very high with slope ranges from 56-70, vegetation cover of 60-80% with a total land area of 10,400.97 ha, and distance to stream is classified as very high with a buffer distance of 401-500 meters. AHP results show precipitation is considered the most influential factor with the computed weighted percentage of 27% with a consistency index of .08 and consistency ratio of .09. The habitat suitability model classified as moderate covers 7,199.09 ha of the total land area.

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