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MAPPING OF LAND SUITABILITY FOR DEVELOPMENT OF VANAME SHRIMP CULTIVATION IN PANGANDARAN REGENCY (SIDAMULIH-PARIGI SUB-DISTRICTS), WEST JAVA PROVINCE

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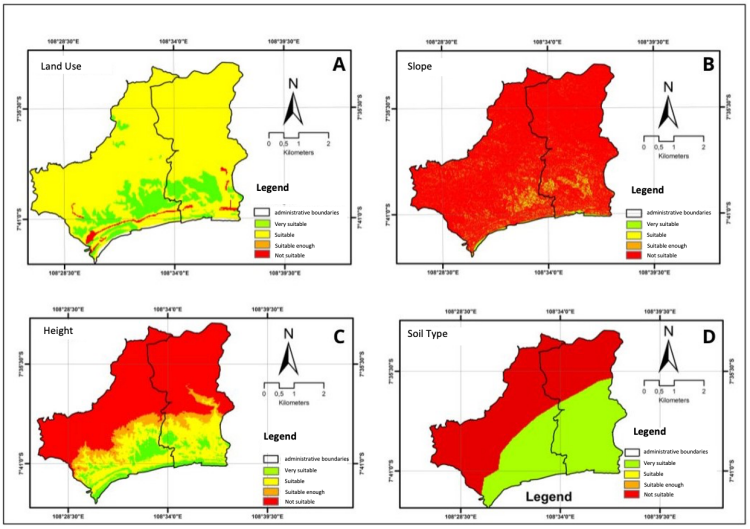

Abstract: Pangandaran Regency has excellent potential for aquaculture development, particularly vaname shrimp ponds along the coast of Sidamulih-Parigi District. However, limited research on regional suitability has contributed to environmental problems and increased coastal vulnerability. Improper pond placement can undermine the efficiency and sustainability of vaname shrimp cultivation. This study aims to assess the potential for developing vaname shrimp cultivation areas around the coast of Pangandaran Regency through multi-criteria spatial analysis and the Analytical Hierarchy Process (AHP). The multi-criteria analysis applied the Inverse Distance Weighted (IDW) interpolation method, multiple ring buffers, and overlays. Three main factors were evaluated: engineering factors (land use, slope, elevation, and soil texture); water quality and quantity (temperature, salinity, distance to seawater sources, and distance from pollution); and infrastructure factors (proximity to roads, markets, processing facilities, and hatcheries). Spatial analysis results show that pond land suitability in the study area is classified into four categories: very suitable (2,921 hectares or 14.64%), suitable (2,753 hectares or 13.79%), moderately suitable (5,294 hectares or 26.52%), and not suitable (8,993 hectares or 45.05%). The coastal zone is largely classified as very suitable due to readily available seawater and flat topography, whereas inland areas are less suitable because of steeper landforms.

Keywords: Mapping; suitability; cultivation; white shrimp; GIS; Pangandaran.

1. Introduction

Indonesia's coastal areas and marine waters hold considerable potential for fisheries development. Continuous population growth and expanding development are correlated with the increasing demand for fishery products. Local

communities are experiencing difficulties in securing livelihoods solely by relying on capture fisheries resources, which are steadily declining [1]. Among aquaculture commodities, Pacific white shrimp (Litopenaeus vannamei) is the most important, accounting for over 50% of the nation's fishery export revenues [2]. In general, pond management practices in Indonesia, especially on Java Island, still require substantial improvement. This is evidenced by the large proportion of abandoned ponds due to crop failures, reaching as high as 70% in Java [3].

In Pangandaran Regency, aquaculture development, particularly shrimp pond farming, is rapidly expanding along the coastal areas. This trend is evident in the increasing number of ponds established in the region, aligning with the Ministry of Marine Affairs and Fisheries (MMAF) priority programs and its vision to position Indonesia as the world's largest fish producer through aquaculture in marine, brackish, and freshwater systems [4].

Subdistricts within Pangandaran Regency possess significant but underutilized potential for marine and fisheries development. According to the Department of Food Security, Marine Affairs, and Fisheries (DKPKP) in 2023, vannamei shrimp farming in Sidamulih and Parigi subdistricts ranks first among aquaculture commodities, with production reaching 20,6990 kg, surpassing other aquaculture products. This production can be further enhanced through management strategies tailored to site-specific potential. Location selection is a critical factor determining aquaculture success [5] (Hossain et al., 2007).

The shrimp farming areas in Sidamulih and Parigi cover a total of 119.500 hectares, with 19.500 hectares located in Sidamulih and 100.000 hectares in Parigi. Several locations in Pangandaran Regency remain understudied and lack comprehensive suitability assessments for shrimp pond development. Previous research in Cijulang and Parigi subdistricts identified three classes of coastal land suitability for aquaculture: highly suitable areas covering 11.7 hectares (49.0%), suitable areas of 1.0 hectare (4.3%), and unsuitable areas spanning 11.1 hectares (46.6%) [1]. Therefore, research assessing land suitability in unstudied parts of Pangandaran is urgently needed. As Rossiter (1996) [6] emphasized, land evaluation is essential because land varies in its physical, social, economic, and geographical characteristics—land is not created equal. One approach for site selection in aquaculture is the application of Geographic Information Systems (GIS) [7] (Meaden & Aguilar-Manjarrez, 2013).

The determination of land suitability levels for vannamei shrimp pond development incorporates several spatially analyzed physico-chemical parameters. The measured parameters include: (1) engineering factors, consisting of land use type, slope, elevation, and soil texture; (2) water quality and quantity factors, including temperature, salinity, distance to seawater sources, and distance from pollution sources; and (3) infrastructure factors, encompassing distance to main roads, markets, processing facilities, and hatcheries. Data processing was conducted using ArcGIS software (Pantjara et al., 2008). This study aims to determine the land suitability classes based on these three factors and to quantify the suitable area as a basis for recommendations for the development of vannamei shrimp aquaculture along the coastal zones of Sidamulih and Parigi Subdistricts, Pangandaran Regency, West Java Province.

2. Results and Discussion

2.1 Topography of the study area

The Sidamulih Subdistrict in Pangandaran Regency exhibits diverse physiographic conditions characterized by several topographic types. The northern part is dominated by hilly mountainous terrain, whereas the southern part consists of fertile lowlands. The rivers that traverse this subdistrict play an important role as water sources supporting aquaculture activities.

Similarly, the Parigi Subdistrict also features varied physiographic conditions, including mountainous areas, lowlands, coastal zones, and river systems. This subdistrict holds substantial potential for aquaculture development in coastal areas, particularly for vannamei shrimp farming.

The land suitability assessment for shrimp ponds was conducted using pairwise comparisons, and the scores assigned to each criterion refer to Hadipour et al. (2015) as presented in Tables 2–5. The land suitability maps for vannamei shrimp aquaculture were categorized into three factors: engineering factors, water quality and quantity factors, and infrastructure factors.

2.2 Pond area suitability based on engineering factors

The water quality and quantity factor comprise four parameters: land use type, slope, elevation, and soil type. The data used for land use analysis were derived from the Pangandaran Regency land use map, while slope and elevation

parameters were extracted from DEMNAS datasets for Pangandaran Regency. Soil type data were obtained from the Food and Agriculture Organization (FAO). All spatial data were processed using ArcGIS software.

In the study area, land use suitability was categorized into three classes: highly suitable, suitable, and moderately suitable. The majority of the area was classified as suitable. According to the criteria used (Table 1), highly suitable areas included ponds, coastal forests, and rice fields; suitable areas comprised plantations and swamp/mangrove forests; and moderately suitable areas corresponded to protected forests (Figure 1A).

The slope parameter in the study area fell into two suitability categories: moderately suitable and unsuitable. The unsuitable class was predominant in inland zones, while moderately suitable areas were mainly located in the coastal zones of Sidamulih and Parigi sub-districts (Figure 1B).

Elevation suitability in the study area was classified into four categories: highly suitable, suitable, moderately suitable, and unsuitable. Highly suitable areas were predominantly found in coastal zones near seawater sources, whereas the other three categories were mainly distributed in inland areas characterized by steeper terrain (Figure 1C).

Soil type analysis, based on FAO data, revealed two dominant soil types in the study area: Litosol (sandy soils) and eutric fluvisol (rocky soils). The coastal zones were largely dominated by highly suitable soils, while unsuitable soils were more common in inland areas (Figure 1D).

The overlay (weighted sum) analysis of all engineering factor parameters produced four suitability classes across the study area: highly suitable (7.86%), suitable (20.61%), moderately suitable (18.18%), and unsuitable (53.34%). Coastal areas were primarily classified as highly suitable and suitable, whereas inland areas were dominated by the unsuitable class.

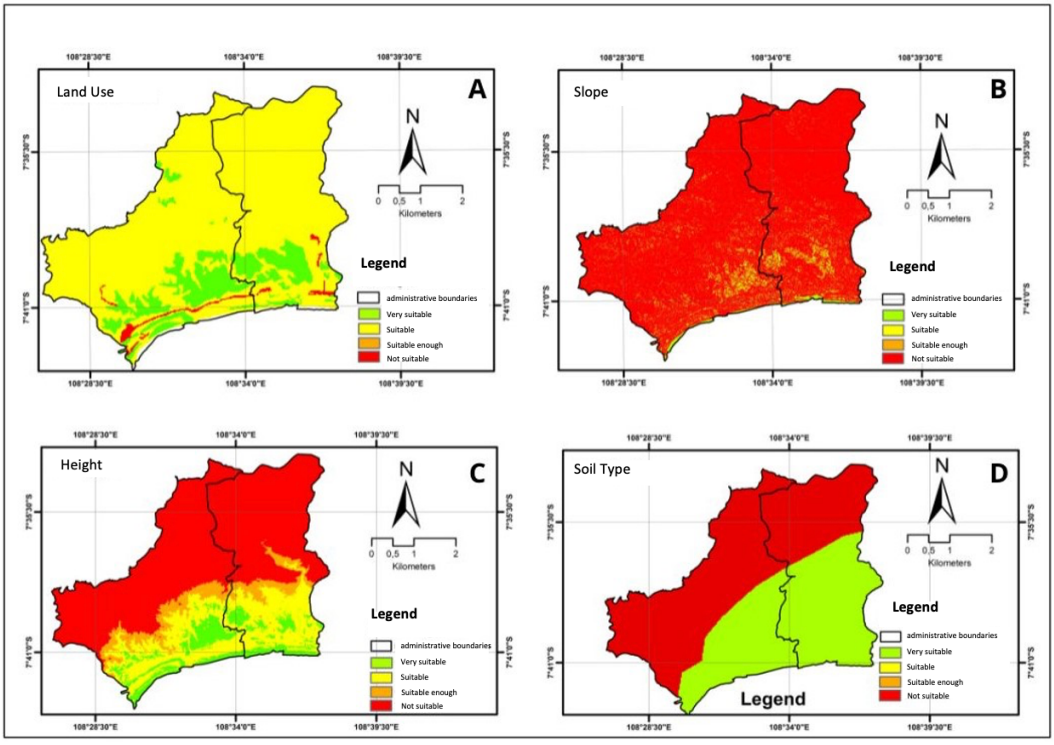

Figure 1. Data processing results for each engineering factor parameter

2.3 Pond area suitability based on water quality factors

The data for water quality and quantity factors were obtained through direct field observations for temperature and salinity parameters. The distance to pollution sources was derived from agricultural land shapefiles, while the distance to seawater sources was determined using coastal shoreline shapefiles of the Pangandaran coastal region.

Water quality and quantity factors included four parameters: distance to seawater sources, water temperature, salinity, and distance to pollution sources. Based on the processed data, the following results were obtained: The temperature parameter across the study area was classified into three suitability classes: highly suitable (28–32 °C), moderately suitable (34–36 °C), and unsuitable (<15 °C). Overall, the temperature data were dominated by the suitable class. Salinity measurements revealed two suitability classes: highly suitable and unsuitable. Field observations showed that salinity in inland

zones averaged 0 ppt, as sampling was conducted in freshwater river areas. In contrast, coastal zones exhibited average salinity ranging from 25 to 30 ppt. Accordingly, the data were predominantly categorized as highly suitable. The distance to pollution sources in the study area was largely influenced by agricultural activities. These agricultural practices contribute pollutants to water bodies, as chemical fertilizers applied in rice fields dissolve and flow into rivers, ultimately discharging into the sea, which serves as the primary water source for shrimp aquaculture. Based on the spatial analysis, this parameter yielded two suitability classes: moderately suitable and unsuitable. The study area was largely dominated by the unsuitable class. The distance to seawater sources parameter was classified into four categories. Coastal zones were categorized as highly suitable, where aquaculture areas are located within less than 1 km of seawater sources. Suitable areas were defined as those 1–2 km away, moderately suitable areas up to 4 km, and unsuitable areas exceeding 4 km. The inland zones were predominantly classified as unsuitable. The weighted overlay analysis integrating all water quality and quantity parameters resulted in three suitability classes: highly suitable, suitable, and unsuitable. In the coastal zones, two classes were identified: highly suitable (15.03%) and suitable (15.43%). Inland zones were predominantly classified as unsuitable, comprising 30.83% of the area.

2.4 Pond area suitabiloty based on infrastructure factors

Infrastructure parameters included distance to the main road, distance to the market, distance to processing facilities, and distance to hatchery sites. Data for the distance to the main road were derived from the road shapefiles of Pangandaran Regency. For the distance to processing facilities, markets, and hatcheries, locations were identified using Google Earth Pro to collect spatial data for these three parameters. The parameter for distance to the main road across the study area was predominantly classified as highly suitable, with most sites located within 1 km of the road. The northern part of the study area was categorized as suitable due to its relatively greater distance of 2–3 km from the main road (Figure 7A). Regarding the distance to markets, there were two main market points identified across both sub-districts. Based on the spatial analysis, three suitability classes were determined: highly suitable, suitable, and moderately suitable. The study area was primarily dominated by the suitable category, with distances ranging from 3–4 km to the nearest market (Figure 7B). For the distance to processing facilities, only one facility was identified, located in Sidamulih Sub-district. The spatial analysis of this parameter yielded four suitability classes: highly suitable, suitable, moderately suitable, and unsuitable (Figure 7C). Regarding distance to hatchery sites, one main hatchery was identified—PT. Biru Laut Nusantara (BLN), located in Parigi Sub-district. This hatchery supplies vannamei shrimp post-larvae to several aquaculture ponds in the Pangandaran area. The coastal zone was classified into two suitability categories: highly suitable and suitable (Figure 7D).

The overall suitability map based on infrastructure factors revealed four suitability categories. Highly suitable areas covered 29.15% of the study area, predominantly located in the coastal regions of Sidamulih Sub-district. Suitable areas accounted for 29.12%, mainly in the central inland zones of Sidamulih and Parigi. Moderately suitable areas comprised 34.09%, distributed across much of the study area, while unsuitable areas represented 7.64% and were concentrated in the northern part of the region.

2.5 Land Suitability Classification for Vannamei Shrimp Aquaculture Development

The map resulting from the combination (overlay) of engineering factors, water quality and quantity factors, and infrastructure factors is presented in Figure 9. This combined map represents the overall study area assessed for the development of vannamei shrimp aquaculture in Sidamulih and Parigi Sub-Districts, Pangandaran Regency.

In the diagram presented above, the infrastructure factor contributed most substantially to the highly suitable and suitable suitability classes, with percentages of 29.15% and 29.12%, respectively. Meanwhile, the moderately suitable class was primarily influenced by water quality and quantity factors, which accounted for the largest contribution at 38.72%. Conversely, the highly unsuitable class was predominantly determined by engineering factors, with a contribution of 53.34%. These findings indicate that infrastructure parameters play an important role in determining land suitability for shrimp pond development in the Sidamulih and Parigi Sub-Districts, Pangandaran Regency.

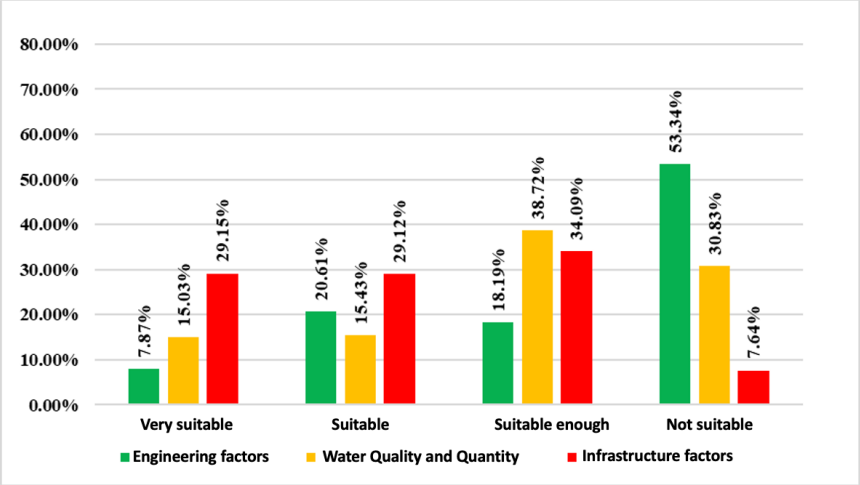

Figure 2. Bar diagram of the percentage of each category of white shrimp cultivation development

In the final suitability map (Figure 2), the coastal zone predominantly falls into the highly suitable class, covering an area of 2,921 hectares. This is attributed to the lowland physiography of the area and the easy access to seawater resources, located only 500 meters from the shoreline. The suitable class mainly occupies the central part of the study area, with a total area of 2,753 hectares, due to its proximity to markets, hatcheries, and river flow. In contrast, the moderately suitable and unsuitable classes are concentrated in the inland and northern parts of the study area, with areas of 5,294 hectares and 8,993 hectares, respectively (Table 1).

Table 1. Pond area suitability classification

No	Suitability class	Area (ha)	Area in %
1	Very suitable	2.921 hektare	14,64 %
2	Suitable	2.753 hektare	13,79 %
3	Moderately suitable	5.294 hektare	26,52 %
4	Not suitable	8.993 hektare	45,05 %

3. Materials and Methods

4.1 Study site

The study area covers the Sidamulih and Parigi Subdistricts, Pangandaran Regency, West Java Province, Indonesia. The mapping of land suitability for vannamei shrimp pond aquaculture was conducted through in-situ observations at thirty-five (35) sampling stations. The observation stations were distributed across coastal and inland zones (Fig.3).

The land suitability assessment for vannamei shrimp pond aquaculture in Sidamulih and Parigi Subdistricts was based on overlay analysis of all suitability parameters using ArcGIS software. Data were collected at 35 sampling points distributed across the two subdistricts. The observation locations were determined through field surveys, during which sampling sites were marked using a Garmin 78s GPS device. Water quality parameters (temperature and salinity) were measured in situ using a water quality checker and a refractometer. Additional data utilized in the analysis included DEMNAS (digital elevation model) data, shapefiles of administrative boundaries, and soil type data obtained from the Food and Agriculture Organization (FAO).

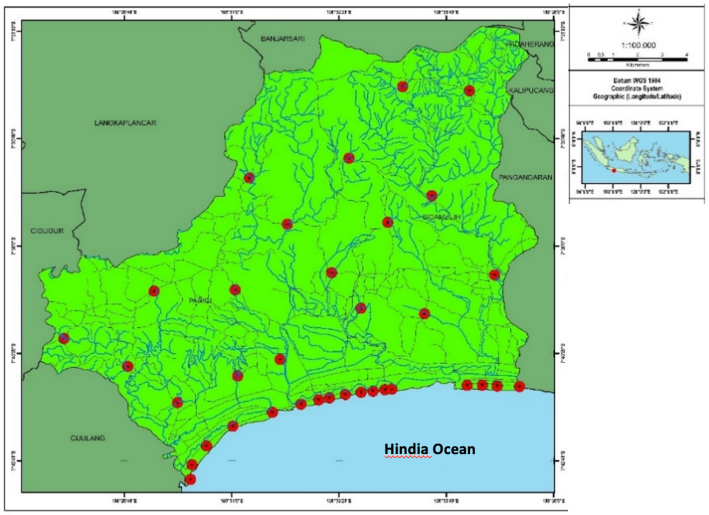

Figure 3. Data collection point for Sidamulih and Parigi Districts in 2024

4.2 Analytical Hierarchy Process

Data analysis in this study employed the Analytical Hierarchy Process (AHP) method and overlay techniques implemented in ArcGIS software. All parameters were processed to generate individual land suitability factor maps, resulting in three separate maps representing engineering factors, water quality and quantity factors, and infrastructure factors. These three factor maps were then overlaid to produce the final land suitability map for vannamei shrimp pond development in Sidamulih and Parigi Subdistricts.

In this study, the weighting of parameters to assess land suitability for vannamei shrimp aquaculture was carried out using the Analytical Hierarchy Process (AHP) method, with the weighting approach adapted from the study by Hadipour et al. (2015) [8]. This approach enabled the researchers to gain a clearer understanding of the relative importance of each parameter in the context of vannamei shrimp farming.

Accordingly, the application of the AHP method provided a systematic means to address the research objectives by leveraging information from relevant literature, as shown in Tables 2–5, which present the weighting applied. The primary focus was to determine the weight assigned to each parameter, which is essential for understanding the relative contribution of each factor to the overall suitability assessment. Therefore, the purpose of determining parameter weights is to address research problems that involve multiple objects and criteria, while taking into account the relative preferences of each element within the decision-making hierarchy [9].

Overlay is the process of superimposing two thematic maps with the same spatial extent to create a new composite map laye. The weighted overlay method is employed in overlay analysis to integrate data from multiple maps representing specific criteria, with the objective of producing information that has a uniform value range. This uniform range reflects the degree of suitability of areas [10].

4.3 Pond area fasibility assessment

The assessment and weighting were conducted through literature analysis and validation by experts with extensive experience in marine and fisheries fields. Scoring was assigned based on the degree of suitability of each parameter within the respective criteria: S1 (Highly suitable), S2 (Suitable), S3 (Moderately suitable), and S4 (Unsuitable). The land suitability assessment for vannamei shrimp ponds referred to the criteria described in previous literature (Hadipour et al., 2015).

The weighting and scoring in this study were based on the literature review by Hadipour et al. (2015). In the weighting and scoring of the engineering factors, the land use type parameter had a relatively high weight of 0.41. For the water quality and quantity factors, the water temperature parameter received the highest weight compared to the other parameters. Regarding infrastructure factors, the distance from the main road parameter was assigned to be a high weight of 0.46.

The land use type parameter, according to Widiatmaka (2007) [11], indicates that highly suitable land uses for vannamei shrimp aquaculture include rice fields and coastal forests, while areas designated as residential or built-up land are considered unsuitable. The slope parameter significantly affects the management of water inflow and outflow in shrimp ponds. Chanractchakool et al. (1995) [12] recommend that suitable aquaculture land should be relatively flat, with slopes less than 2% classified as highly suitable and slopes greater than 10% as unsuitable (see Table 1). Regarding soil type,

Setiaji et al. (2018) [9] classify alluvial and lithosol (sandy) soils as highly suitable for vannamei shrimp ponds, whereas eutric fluvisol (rocky soils) are deemed unsuitable. Finally, the elevation parameter considered highly suitable for shrimp ponds ranges from 2 to 2.5 meters, while elevations above 5 meters are unsuitable [8].

Water quality and quantity parameters, particularly temperature, play a critical role in vannamei shrimp aquaculture. The optimal temperature range considered highly suitable is 28–32 °C, while temperatures exceeding 36 °C or below 15 °C are classified as unsuitable [8]. Temperature affects various aspects of shrimp biology, including survival, morphological growth, reproduction, behavior, molting, and metabolism. Elevated water temperatures can also reduce dissolved oxygen levels [13]. Regarding salinity, Boyd (1995) [14] noted that vannamei shrimp exhibit broad tolerance to salinity variations, enabling them to survive and grow even under relatively low salinity conditions. However, the most suitable salinity range for cultivation is 30–40 ppt.

The parameter of distance to the seawater source, often referred to as seawater reach distance, describes the proximity between pond sites and coastal water sources. Ideally, pond locations should be situated close to seawater sources. An optimal distance is considered less than 1 km, while distances exceeding 4 km are categorized as highly unsuitable. Finally, the parameter of distance from pollution sources is also essential in site selection. A minimum distance of 4 km from major pollution sources is recommended, while distances less than 1 km are regarded as unsuitable for vannamei shrimp farming.

The distance to market is a key parameter for the economic viability of vannamei shrimp farmers. According to Hadipour et al. (2015) [8], an appropriate distance between aquaculture sites and markets is approximately 3 km, while a distance of 12 km or more is considered unsuitable. The distance to main roads is another important infrastructure parameter, as it directly affects the logistics of harvesting and transporting shrimp. The most suitable sites are located less than 1 km from main roads, whereas sites situated more than 10 km away are regarded as unsuitable (Table 1). The distance from processing facilities is also crucial for maintaining product quality and reducing transportation costs. Ideally, the distance from ponds to processing centers should be around 3 km, while distances exceeding 12 km are considered highly unsuitable [8]. Finally, the distance from hatcheries to grow-out ponds is essential to ensure reliable and timely seed supply. The most suitable sites are within 3 km of hatcheries, while distances greater than 12 km are categorized as unsuitable for vannamei shrimp aquaculture.

5. Conclusions

The results of this study indicate that the suitability of land for vannamei shrimp farming in Sidamulih and Parigi Sub-Districts can be classified as follows: the highly suitable category (S1) covers an area of 2,921 hectares (14.64%), the suitable category (S2) covers 2,753 hectares (13.79%), the moderately suitable category (S3) encompasses 5,294 hectares (26.2%), and the unsuitable category (S4) comprises 8,993 hectares (45.05%). The coastal zone predominantly falls within the highly suitable category, while the inland zone is mainly classified as unsuitable. In the final suitability map, the engineering factor contributed most substantially to the highly suitable and suitable classes, with values of 29.15% and 29.12%, respectively. The moderately suitable class was primarily influenced by water quality and quantity factors, whereas the unsuitable class was mainly determined by infrastructure factors, with a contribution of 53.34%

It is recommended that further validation of the land suitability matrix for vannamei shrimp farming be conducted to ensure the robustness and reliability of the classification results. Additionally, integrating supplementary environmental data, such as rainfall patterns, tidal fluctuations, and water pH, into future analyses would enhance the precision and comprehensiveness of the land suitability assessment for shrimp aquaculture development in the study area.

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References

1. Syaugy, A.; Siregar, V.P.; Arhatin, R.E. Evaluasi Kesesuaian Lahan Tambak Udang di Kecamatan Cijulang dan Parigi, Ciamis, Jawa Barat. *J. Teknol. Perikan. Kelaut.* **2017**, *3*, 43–56. https://doi.org/10.24319/jtpk.3.43-56.
2. Sulnidar; Laopo, A.; Nurmedika. Analisis Pendapatan Usaha Tambak Udang Vannamei di Desa Tolai Timur Kecamatan Torue. *J. Agribisnis Perikan.* **2022**, *10*, 278–286.
3. Kordi, M.G.H.; Tancung, A.B. *Pengelolaan Kualitas Air*; PT Rineka Cipta: Jakarta, Indonesia, 2007; 238 pp.
4. Marza Arisandi, D.; Saifullah; Bakar Sambah, A. Pemetaan Potensi Pengembangan Perikanan Budidaya di Wilayah Pesisir Kota Probolinggo. *J. Ilmu Perikan. Kelaut.* **2022**, *4*, 1–13.
5. Hossain, M.S.; Chowdhury, S.R.; Das, N.G.; Rahaman, M.M. Multi-criteria evaluation approach to GIS-based land-suitability classification for tilapia farming in Bangladesh. *Aquac. Int.* **2007**, 15, 425–443. https://doi.org/10.1007/s10499-007-9109-y.
6. Rossiter, D.G. A theoretical framework for land evaluation. *Geoderma* **1996**, *72*, 165–190. https://doi.org/10.1016/0016-7061(96)00031-6.
7. Meaden, G.J.; Aguilar-Manjarrez, J. *Advances in Geographic Information Systems and Remote Sensing for Fisheries and Aquaculture*; FAO Technical Paper; FAO: Rome, Italy, 2013. https://doi.org/10.13140/RG.2.1.4037.7682.
8. Hadipour, A.; Vafaie, F.; Hadipour, V. Land suitability evaluation for brackish water aquaculture development in coastal area of Hormozgan, Iran. *Aquac. Int.* **2015**, *23*, 329–343. https://doi.org/10.1007/s10499-014-9818-y.
9. Setiaji, K.; Nugraha, A.L.; Firdaus, H.S. Analisis Kesesuaian Lahan Tambak terhadap Produktivitas Budidaya Udang Menggunakan SIG (Studi Kasus: Kabupaten Kendal). *J. Geodesi Undip* **2018**, *7*, 128–137.
10. Akbarurrasyid, M.; Kristiana, I. Analisis Spasial Multi Kriteria untuk Menentukan Kesesuaian Lahan Tambak Budidaya Udang Vannamei (*Litopenaeus vannamei*): Biogeofisik dan Kualitas Tanah. *Samakia: Jurnal Ilmu Perikanan* **2020**, *11*, 79–90. https://doi.org/10.35316/jsapi.v11i2.826.
11. Widiatmaka, H. *Evaluasi Lahan dan Perencanaan Tataguna Lahan*; IPB Press: Bogor, Indonesia, 2007. https://www.researchgate.net/publication/281685196_Evaluasi_Lahan_dan_Perencanaan_Tataguna_Lahan.
12. Chanratchakool, P.; Turnbull, J.F.; Funge-Smith, S.; Limsuwan, C. *Health Management in Shrimp Ponds*, 2nd ed.; Aquatic Animal Health Research Institute, Department of Fisheries: Bangkok, Thailand, 1995; 111 pp.
13. Ikbal, M.; Agussalim, A.; Fauziyah. Evaluasi Status Kesesuaian Lahan Tambak Udang Vaname (*Litopenaeus vannamei*) Menggunakan Sistem Informasi Geografis (SIG) di Tambak Bumi Pratama Mandira Kabupaten Ogan Komering Ilir, Sumatera Selatan. *Maspari J.* **2019**, *11*, 69–78.
14. Boyd, C.E. *Bottom Soils, Sediment, and Pond Aquaculture*; Chapman and Hall: New York, NY, USA, 1995.