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# Application of the spatial model of road trace development in the swamp area of Banyuasin District

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## Abstract

Planning for road network development in swampy areas is inseparable from determining road trace to obtain a suitable road network layout. The suitability of geological, topographic, soil, hydrological and land use conditions is a matter that must be considered, coupled with other issues such as land value, land ownership, social and economic impacts, and identification of environmentally sensitive areas. There are nine components that are considered in determining road trace in swamp areas in order to obtain environmentally sound road construction, namely: soil texture, puddle, CBR value, peat soil, land use, average daily traffic, tonnage, accessibility, and sociogeography. This study aims to obtain a road trace in an environmentally friendly swamp area using a road trace model in swamp areas developed by Indrayani, et al in 2019. The application was carried out in the swamp area of Banyuasin district, South Sumatra province, by taking the 9 components in the recommendation. The method used in this research is remote sensing in the introduction of the physical environment, while the scoring and weighting methods use multicriteria spatial analysis in determining the suitability of the area.. From the modeling results, it is found that the suitable area for road alignment is 136.66 km2, which is quite suitable for 3151.66 km2, and which is very inappropriate is 39.71 km2. Meanwhile, the road alignment that connects between districts in the study area is obtained in the form of a thematic map.

**Keywords:** Application; Spatial Model; Road Trace; Swamp area

## 1. Introduction

The development of road alignment must pay attention to existing environmental conditions in order to achieve sustainability of development. Sustainable development will be difficult to achieve if development policies do not rely on the potential of human resources, natural resources, and artificial resources [1][2][3][20]. At present the development of swamp areas is increasingly being carried out considering the increasingly limited productive land and besides that the government continues to develop swamp areas in the agricultural, plantation, fishery sectors [4]. To support the development of swamp areas, road infrastructure is needed. The existence of road infrastructure must pay attention to the condition of the swamp area. For this reason, engineering is needed in determining the suitability of road alignments that are environmentally sound so that the function of the swamp area ecosystem is maintained without reducing the functions and benefits of the road network system to be built. Conditions in the field indicate that road damage that occurs in swamp areas is in the form of subsidence, cracks and distortion of the road body. One of the contributing factors is the unstable soil conditions. This is because the soil constituents in swamp areas are finely textured soils containing clay minerals and organic matter [4][5]. Therefore, in planning the road alignment in swamp areas must take into account environmental factors.

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Planning for road network development in swamp areas is inseparable from determining road alignment to obtain suitability in road network layout. The suitability of soil conditions, geology, topography, hydrology, and land use are things that must be considered, coupled with other issues such as land value and ownership, social and economic impacts, and identification of environmentally sensitive areas. There are nine components that are considered in determining road alignment in swamp areas in order to obtain environmentally sound road construction, the nine components are: 1) soil texture, 2) inundation, 3) CBR value, 4) soil peat (physical environmental aspects), 5) land use aspects, 6) Average Daily Traffic, 7) vehicle tonnage, 8) accessibility, 9) sociogeography (socio-economic aspects) [7][8][9].

Several studies on spatial have been carried out, including: Analysis in spatial planning as a support for spatial decisions can be carried out using the Spatial Multi Criteria Analysis (SMCA) where the results are presented spatially which shows the area of suitability which is very helpful in making decisions or policies [15][17]. Although many studies have used GIS methods based on spatial multicriteria to assess environmental impacts [16][19], the use of spatial techniques in determining initial alignment is still rarely used [13]. And research on the spatial model for determining road alignment in swamp areas has been carried out, the results show that there are 9 components that are considered by the model [7][8][9].

## 2. Methods

### 2.1. Study area

This research was conducted in daerah rawa Kabupaten Banyuasin, due the topography of the Banyuasin Regency area consists of 80% wet lowlands with a slope of 0 - 8% covering an area of 1,181,610 hectares and 8 - 15% covering an area of 1,689 hectares. The area of study can be seen in Figure 1.

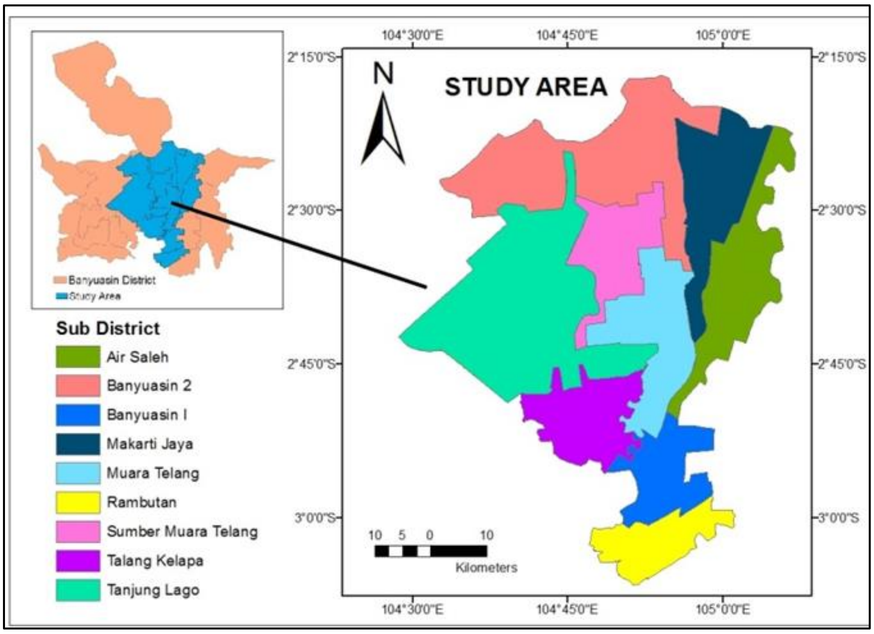


**Figure 1** Map of the study area in the Banyuasin District

To provide a clear representation of the geometric configuration used in the numerical simulations, the rotor design is illustrated in Figure 1. Figure 1 illustrates the three-dimensional geometry of the floating pico-hydro turbine used in the simulation. The rotor configuration was developed to operate at moderate river flow velocities, typically 1.0–1.5 m/s. The design emphasizes compact dimensions suitable for floating deployment in shallow river environments. The geometric model defines the rotor diameter, blade arrangement, and submergence condition that directly influence flow interaction and torque generation.

### 2.2. Research stage

The research stages were started from (1) image interpretation to obtain a thematic map of the physical condition and land use in the study area using interpretation of Landsat 8 satellite imagery downloaded from United States Geological

Survey [18], December 5, 2016 on scene: path 124/ row 062. Satellite image analysis includes: landuse and land cover classification, inundation classification based on water level from the ground surface, soil texture classification, and CBR value based on soil texture conditions [9]; (2) preparation of thematic maps of all reviewed parameters, including maps of land use classifications, maps of inundation classifications, maps of soil texture classifications, maps of CBR value classification, maps of peat classification, maps of average daily traffic classification compiled based on sub-district boundaries and potential study areas, maps of tonnage classification are arranged based on sub-district boundaries and potential areas, maps of accessibility classifications are prepared based on the potential areas and the existing road network accessibility index, and maps of Sociogeographic classification is arranged based on the layout of the river in the study area and potential areas; (3) structuring the spatial database structure to store all information related to interconnected spatial data, so that it can be used quickly and easily in data access, includes land cover/landuse, puddles, soil texture, CBR, peat, average daily traffic, tonnage, accessibility, and sociogeography. and each parameter being reviewed is a criteria map in the data analysis process; (4) weighting each parameter reviewed; (5) standardize based on parameter weights; (6) Spatial Multi Criteria Analysis (SMCA) uses the following mathematical equations:

$$W = Wa\ (Wb\ (Wc\ (...... + Wn\ (V_1/V_{1max}) + W_{1\text{-}n}\ (1\text{-}V_{2max})) + ....W_{1\text{-}c}\ (....) + W_{1\text{-}b}\ (....) * W_{1\text{-}a}\ (....))$$

Where: W = weight of suitability area; Wa, b, c, ...., n = weights for class a, b, c or factor n; W1-a, b, c, ...., n = weights per factor group (all of which are 1); V1,2 = factor value 1, 2 (indicator); V1,2 max = maximum value of the factor 1,2 used for standardization.

Determination of the selected road alignment is carried out using equation (2), the higher the weight, the better the value and is the most appropriate location to be taken as a road alignment in swampy areas.

$$Wx = (V\ x / V\ x\ max)$$

Where: Wx = weight of suitability area; Vx = factor value; Vxmax = maximum value.

### 2.3. Classification of parameters

The classification method for road alignment parameters in swamp areas, namely: (1) classification of land use using the supervised classification method on the composite band 654, (2) classification of puddle using the NDWI method, (3) classification of soil texture using the NDSI method, (4) classification of the CBR value is carried out based on an approach from soil texture, (5) classification of peat soil is carried out based on the Indonesian wetland peat map and the Banyuasin peat area map, (6) the classification of the type of road service, the average daily traffic is divided based on the function of the road, (7) the classification of the type of road service, the tonnage of the vehicle is classified by road class, (8) classification of road service types based on the value of the accessibility index is taken from the performance of the minimum service standards from the availability of a road network that is easily accessible to the public which is obtained from the comparison of road lengths to the area, and (9) the classification of road service types based on sociogeographic conditions is taken from the pattern of community settlements in swampy areas or lowland areas tend to follow river flow patterns [6]. Scoring is done for each classification based on the level of suitability of each criterion. The scoring of the level of suitability of inundation, soil texture, CBR value, and peat can be seen in Table 1 and Table 2.

**Table 1** Scoring of parameters maps of puddle, soil texture, CBR values, and peat soil

| **No** | **Variable** | **Conformity Criteria** | | |
|---|---|---|---|---|
| | | Very Insuitability (1) | Quite Suitability (2) | Suitability (3) |
| 1 | Puddle | > 50 cm (High Puddle) | 20 – 50 cm (Medium Puddle) | 0 – 20 cm (Low Puddle) |
| 2 | Soil Texture | < 0,002 mm (Clay) | 0,002 mm – 0,075 mm (Silt) | 0,075 mm – 0,425 mm (Fine Sand) |
| 3 | CBR Value | < 3 % (Bad) | 3 – 5 % (Quite Good) | 5 – 15 % (Good) |
| 4 | Peat Soil | 100 – 200 cm (Medium Peat) | 50 – 100 cm (Peat Shalllow) | < 50 cm (Peat) |

**Table 2** Scoring of parameters maps of average daily traffic, tonnage, accessibility, and sociogeography

| No | Variable | Conformity Criteria | | |
|---|---|---|---|---|
| | | **Very Insuitability (1)** | **Quite Suitability (2)** | **Suitability (3)** |
| 1 | Average Daily Traffic | > 700 pcu/hour (Local Road) | > 10.000 pcu/hour (Primary Collector Street) | > 20.000 pcu/hour (Secondary Arterial Street) |
| 2 | Tonnage | 8 ton (Street of Class II / III) | 10 ton (Street of Class I) | > 10 ton (Special Street) |
| 3 | Accessibility | Low area potential, medium accessibility index | Medium area potential, low accessibility index | High potential area, very low accessibility index |
| 4 | Sociogeography | > 2500 m from river (Far) | 1500 – 2500 m from river (Quite Far) | 0 – 1500 m from river (Near) |

## 3. Results and discussion

Classification of criteria map of road traces in swampy areas

The map of the classification interpretation results of the road alignment parameters can be seen in Figure 2.

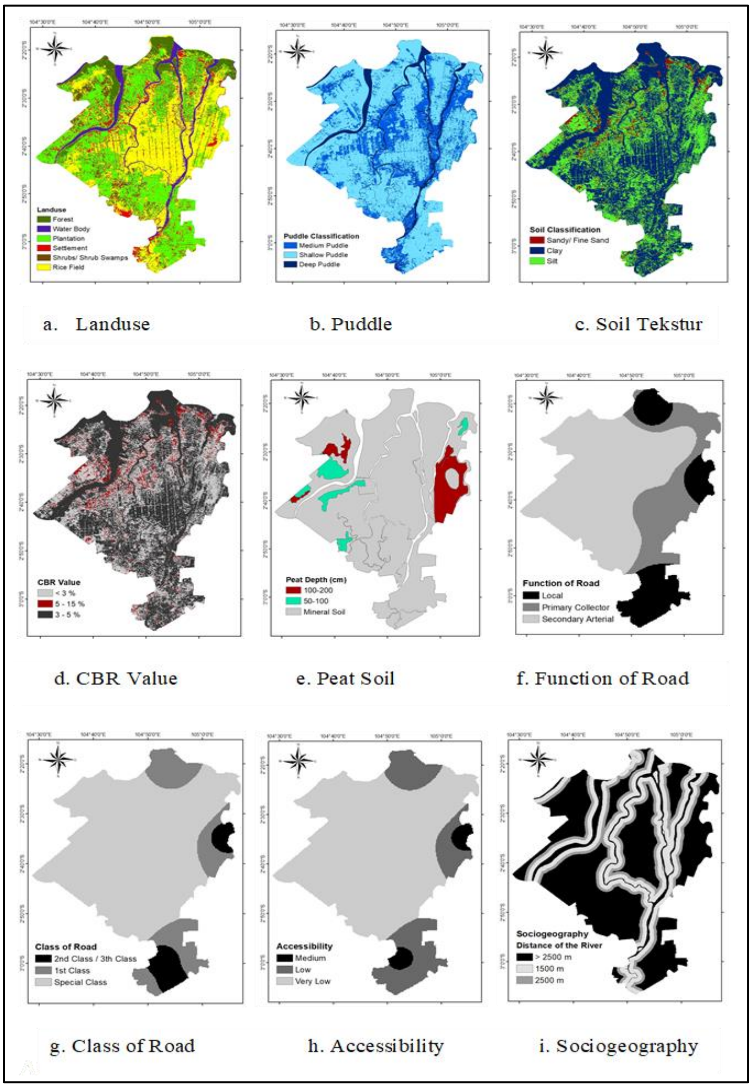


**Figure 2** Classification of road alignment parameters in swampy areas

From Figure 2 it can be seen that the land use map is divided into 6 classes, while the inundation classification, soil texture, CBR value, peat, road function, road class, accessibility index and road services are divided into 3 classes. Most of the land use in the study area consists of plantations and rice fields, while for the built area it is still relatively small so that a road network is needed to support the development of the area [6][14]. Meanwhile, from the aspect of the physical environment (Figure 2b, 2c, 2d and 2e) indicates that the study area is a flooded area, mostly of fine-textured soil and in some areas consists of peat soil, and has a low CBR value. Physical environmental factors must be considered to maintain road sustainability in swampy areas. The results showed that the current function of roads generally functions as secondary arterial roads and in some areas it functions as local and primary roads. The class of roads in the area is dominated by special roads because they are intended for plantation areas with very low accessibility levels. Meanwhile, in terms of sociogeography, it can be seen that the road planning distance is based on the river buffer distance.

### 3.1. Weighting of physical environmental

Scoring on the map criteria for inundation, soil texture, CBR value, and peat based on applicable assessment standards and adjusted to the results of previous research [7]. The scoring and weighting results show that the most important criterion of physical components to consider in determining road trace decisions in swamp areas is the CBR value, this is because the CBR value of the soil will affect the construction above it, which is 38.73%, while the second factor need to be considered is inundation conditions, roads built in inundated areas will result in piling up in the inundated area so that it can damage the existing swamp environmental conditions, the percentage of weight is 24.52%, and then the soil texture and peat soil.

Furthermore, the thematic map weights are combined using the weighted overlay method. The results of the weighted overlay can be seen in Figure 3.

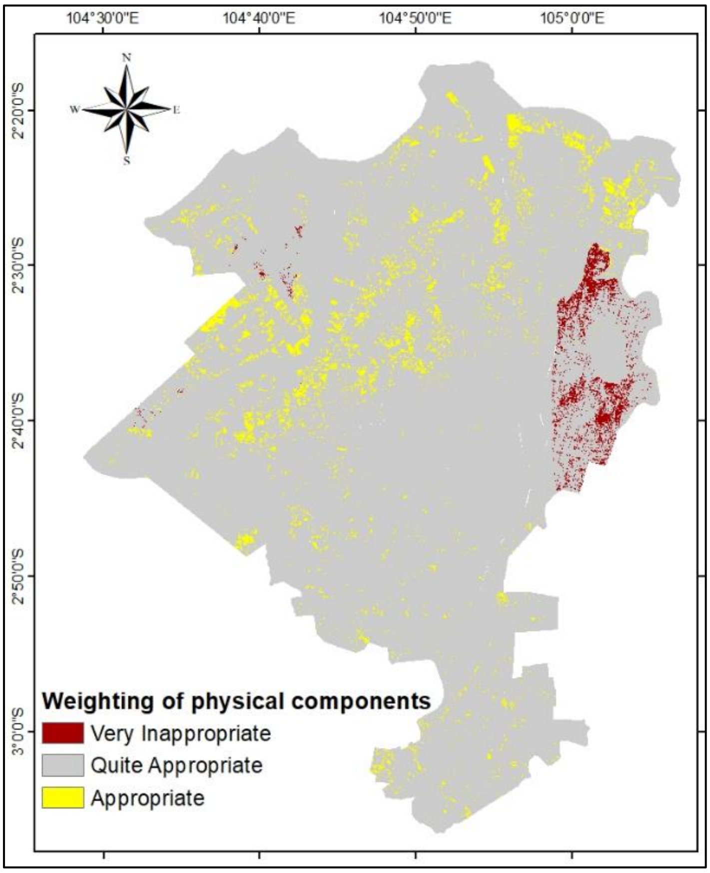


**Figure 3** Result of Weighting Overlay Physical Components of Road Trace Suitability

### 3.2. Weighting of land use parameters

The land use component is divided into 6 classes including forest areas, plantations, settlements, rice fields, shrubs, and water bodies (Figure 6a). The best area to be selected as a road trace is shrubs with a weight of 29.99%, due to the economic considerations of taking shrubs as a more economical road trace, then plantation areas, rice fields, settlement, forests and finally water bodies (rivers) which is 7.22%. The thematic map of land use does not need to be standardized because the weighting is already in the range of 0-1 [8][11][12].

### 3.3. Weighting of socio-economic parameter

Weighting on the map the criteria for average daily traffic, tonnage, accessibility, and sociogeography based on applicable assessment standards and adjusted to the results of research conditions in swamp areas. The highest weight that needs to be considered in selecting a road trace is the tonnage factor, which is equal to 36.65 %, due the weight of the vehicle greatly affects road conditions and most of the natural resource products are in the form of plantations and agriculture which in distribution require road infrastructure. Furthermore, accessibility is the second factor that needs to be considered in determining road trace, namely is equal 25.37%, due with the consideration that the road being built will provide easy access in achieving destination areas and subsequently sociogeographic factors and average daily traffic [8].

Furthermore, the scoring results from the criteria map are overlaid to obtain a map of the suitability of the socio-economic aspects using the weighted overlay method. The overlay results can be seen on the thematic map in Figure 4.

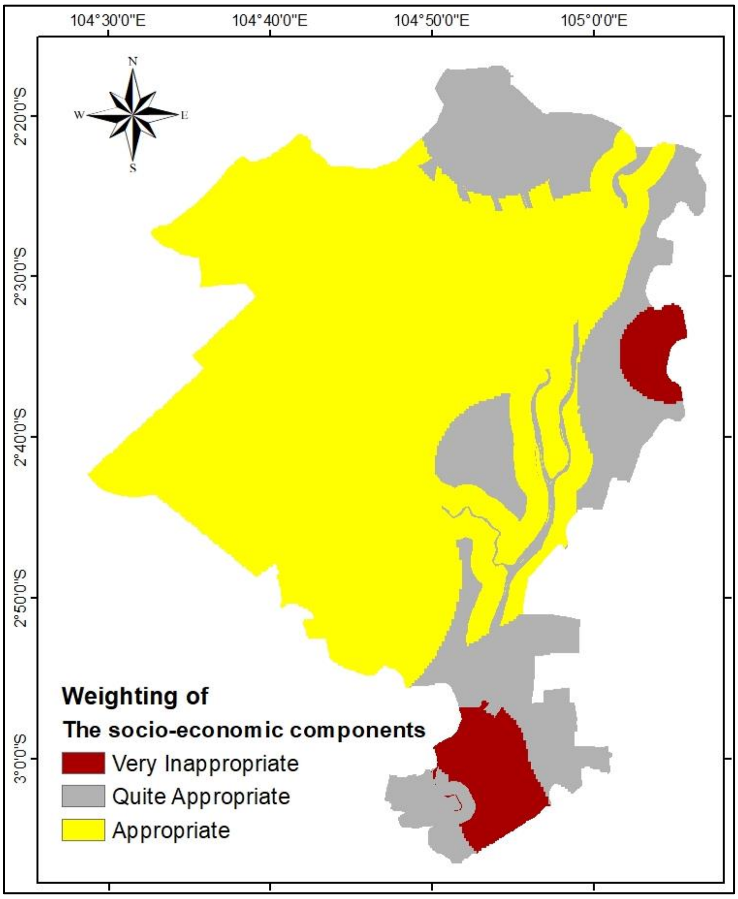


**Figure 4** Result of weight overlay of Socio-Economic Components

From the results of the overlay of the socio-economic components, it shows that most of the study areas are suitable for road construction due to the ongoing development of the swampy areas so that they need to be supported by road infrastructure.

### 3.4. Spatial model of road trace in swamp areas

The model built in determining road alignment is a spatial analysis of the suitability of swamp areas based on 9 components including land use, inundation, soil texture, CBR value, peat, average daily traffic, tonnage, accessibility, and sociogeography. The implementation of the spatial analysis model will be applied by drawing road trace from the activity center in each sub-district in the study area.

The spatial analysis model of the suitability of the area for this road trace focuses on physical environmental aspects (inundation, soil texture, CBR values and peat soil); socio-economic aspects (average daily traffic, tonnage, accessibility, and sociogeography), as well as land use. The results of spatial modeling of road trace suitability in swamp areas with comparisons of physical environment components: land use components: socio-economic environmental components (50%: 20%: 30%) can be seen in Figure 5.

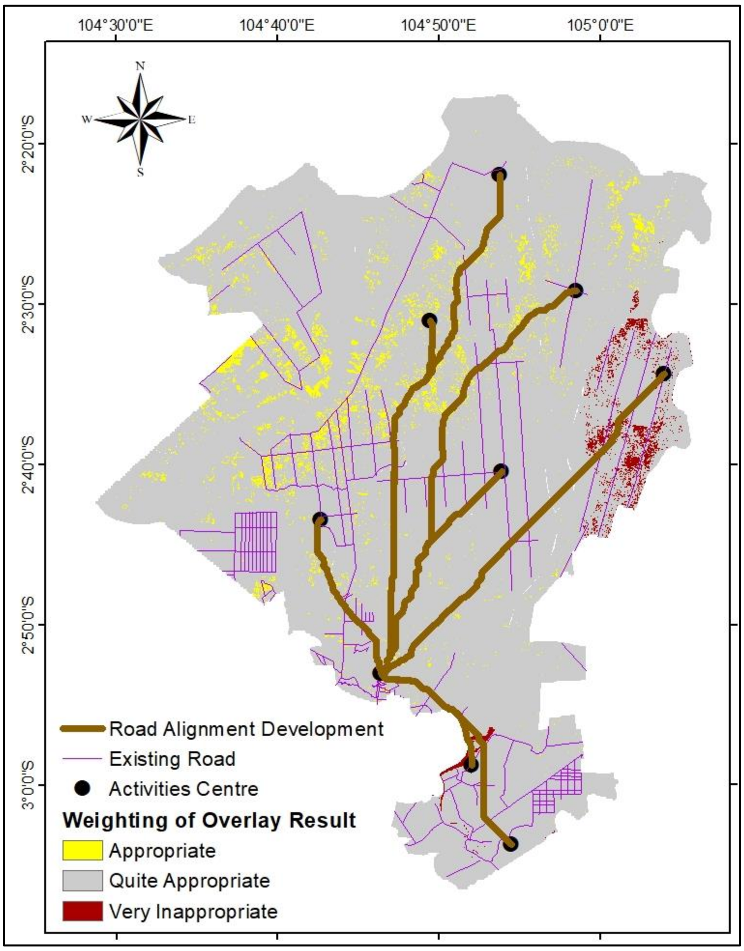


**Figure 5** Result of Road Trace Development Modeling

Figure 5 shows that the suitable area taken as a road alignment is 136.66 km2, quite suitable is 3151.66 km2, and the most inappropriate is 39.71 km2. The length of the road trace that connects the activity center in the Talang Kelapa sub-district to the activity center in other sub-districts in the Banyuasin Regency area is shown in Table 3.

**Table 3** Road Length of Spatial Modeling Application Results

| No. | Origin | Destination | Length (km) |
|---|---|---|---|
| 1. | Talang Kelapa Sub District | Banyuasin I Sub District | 17.00 |
| 2. | Talang Kelapa Sub District | Rambutan Sub District | 28.15 |
| 3. | Talang Kelapa Sub District | Tanjung Lago Sub District | 20.84 |
| 4. | Talang Kelapa Sub District | Air Salek Sub District | 48.75 |
| 5. | Talang Kelapa Sub District | Muara Telang Sub District | 43.35 |
| 6. | Talang Kelapa Sub District | Sumber Marga Telang Sub District | 29.28 |
| 7. | Talang Kelapa Sub District | Banyuasin II Sub District | 62.22 |
| 8. | Talang Kelapa Sub District | Makarti Jaya Sub District | 55.13 |

## 4. Discussion

The fundamental difference in road planning in highlands and swamps is the consideration of land contour/elevation. In highlands, contour is necessary to determine vertical alignment to achieve ideal road surface elevations. In swamps, however, contour is not a primary consideration and can even be omitted because the land surface tends to be flat [5][12]. Based on the results of this study, the primary consideration in selecting roads in swampy areas is the existing inundation conditions, given that swampy areas are always flooded [7]. Based on the results of this study, the primary consideration in selecting roads in swampy areas is the existing inundation conditions, given that swampy areas are always flooded [7][10]. When designing roads, the road surface must be elevated above the floodwater level to avoid inundation. Roads that are easily flooded are susceptible to damage and instability, which will reduce sustainability.

Environmental conditions that greatly influence planning in swamp areas include (i) soil conditions, soil in swamp areas tends to have low bearing capacity so that road construction is susceptible to deformation, (ii) flat topography and below the flood water level, causing the plains to be easily flooded, this causes road construction to be susceptible to damage, such as the release of asphalt bonds...

## 5. Conclusion

Nine components are considered in determining road alignment in swampy areas, namely: (a) land use; (b) puddle; (c) soil texture; (d) CBR value; (e) peat soil; (f) average daily traffic; (g) vehicle tonnage; (h) accessibility, and (i) sociogeography. Comparison of the components of the physical environment: components of land use: components of the socio-economic environment in determining road alignment in swamp areas is 50% : 30% : 20%. Environmental aspects have the highest weight in road construction in swamp areas because the characteristics of swampy areas are very complex where this area has a low carrying capacity but has a very important function in maintaining environmental balance. From the modeling results, it is found that the suitable area for road alignment is 136.66 km2, which is quite suitable for 3151.66 km2, and which is very inappropriate is 39.71 km2. Meanwhile, the road alignment that connects between districts in the study area is obtained in the form of a thematic map.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The authors declare no conflict of interest.

## References

[1] Saputra, R, H., Indrayani, Mirza, A., Najib, A., Prakoso, M.A., Anjani, W. A., 2024. “Identification of Flood Distribution Per District Based on GIS in Palembang City”. *Atlantis Highlights in Engineering* 7 th FIRST 2022 International Conference (FIRST-ESCSI-23) pp 104 - 117.

[2] Sudarmadji, Indrayani, Praditya, N., Idrat, V., Siahaan, Y. 2024. “The identification of retention ponds for flood management in Palembang City.” *Atlantis Highlights in Engineering* 7 th FIRST 2022 International Conference (FIRST-ESCSI-23) pp 177 - 185.

[3] Idrat, V., Indrayani, Mirza. A., Prayoga. T., Azzahra Ramadhanti, A Analysis of Flood Discharge Changes in the Watershed of the Bendung Area, Palembang City. *Atlantis Highlights in Engineering* 8 th FIRST 2024 International Conference (FIRST-ESCSI-24) pp 364 - 373. https://www.atlantis-press.com/proceedings/first-escsi-24/126010428

[4] Alihamsyah, T., Ananto, E.E., Supriadi, H., Ismail, I.G., Sianturi, D.E., 2000. “Dwi Windu Penelitian Pertanian Lahan Rawa: Mendukung Pertanian Masa Depan”. Pusat Penelitian dan Pengembangan Tanaman Pangan, Bogor.

[5] Andriani., Hadie, M.S.N., Asema, F., 2019a. “The Effect of Geotechnical Characteristics Toward Road Damage at Lowland Area”. Journal of Physics: Conference Series 1500 (2020) 012078 IOP Publishing. doi:10.1088/1742-6596/1500/1/012078.

[6] Andriani., Ibrahim.E., Putranto, D.D.P., Affandy. A.K., Putra, H.G., 2019b. "Spatial analysis of land subsidence potential due to lowland conversion (case study at Tanjung Api-Api)". IOP Conf. Series: Materials Science and Engineering 933 (2020) 012054 IOP Publishing. doi:10.1088/1757-899X/933/1/012054.

[7] Indrayani., Buchari, E., Putranto, D.D.A., Saleh, E. 2018. "Spatial analysis of soil texture and peat soil by NDSI method at swamp area of Banyuasin District, Indonesia". Ecology, Environment and Conservation Journal, Vol. 24 (2), 673-680.

[8] Indrayani., Buchari, E., Putranto, D.D.A., Saleh, E., 2018a. "The analysis of land use weights on road traces selection", https://doi.org/10.1051/matecconf/201819504018.

[9] Indrayani., Buchari, E., Putranto, D.D.A., Saleh, E., 2018b. "Spatial analysis of soil texture and peat soil by NDSI method at swamp area of Banyuasin District, Indonesia". Ecology, Environment and Conservation Journal, Vol.24, No.2: 674-680, ISSN 0971 – 765 X.

[10] Indrayani., Buchari, E., Putranto, D.D.A., Saleh, E., 2018c. "Analysis of Puddles in swamp area of Banyuasin District using the imange Landsat 8 by NDWI method". Ecology, Environment and Conservation Journal, Vol.24, No.3: 1069-1075, ISSN 0971 – 765 X.

[11] Indrayani., Buchari, E., Putranto, D.D.A., Saleh, E. 2017. "Analysis of landuse in the Banyuasin district using the image Landsat 8 by NDVI method". AIP Conference Proceedings 1903, 030007, https://doi.org/10.1063/1.5011514..

[12] Indrayani., Buchari, E., Putranto, D.D.A., Saleh, E., 2016. "The Analysis of Geotechnical and Topographical Aspects Based on GIS as Initial Identification of Road Alignment Determination on Swamp Areas." ICSBE Proceedings, ISSN 2541-223X; 12 – 14.

[13] Keshkamat, S., 2007. "Formulation and Evaluation of Transport Planning Alternatives using Spatial Multi Criteria Assesment and Network Analysis: A Case Study of North-Eastern Poland". Master Thesis, International Institute for Geo-Information Science and Earth Observation (ITC), Netherlands.

[14] Putro dan Nurhamsyah, 2016. "Pola Permukiman Tepian Air (Studi Kasus : Desa Sepuk Laut, Punggur Besar dan Tanjung Saleh Kecamatan Sungai Kakap, Kabupaten Kubu Raya". Jurnal Langkau Betang, Vol. 2, No.1: 65 -76

[15] Raaijmakers, R.J.J., 2006. "A Spatial Multi Criteria Analysis Methodology for the Development of Sustainable Flood Risk Management in the Ebro Delta". University of Twente Department Water Engineering and Management.

[16] Subramani, T., Nanda, S.K., 2012. "National Highway Alignment Using GIS". International Journal of Engineering Research and Applications (IJERA), Volume 2, Issue 4, July-August: 427 – 436.

[17] Sulistyorini, R., dan Dwi, H., 2010. "Analisis Multi Kriteria Sebagai Metode Pemilihan Suatu Alternatif Ruas Jalan di Propinsi Lampung". Jurnal Rekayasa, Volume 14, No. 3, ft-sipil.unila.ac.id/ejournals/index.php/ jrekayasa/article.

[18] USGS, 2019. "Landsat 8 (L8) Data Users Handbook". U.S. Geological Survey. South Dakota: Department of the Interior..

[19] Blaser, B., Liu, H., McDermott, D., Nuszdorfer, F., Phan, N., Vanchindorj, U., Johnson, L., Wyckoff, J., 2004. "GIS Based Cumulative Effect Assessment, Colorando Department of Transportation". Research Report. http://www.dot.state.co.us/Publicaton/PDFFiles.

[20] Dardak, H., 2005. "Spatial Planning-Based Development of the Sumatra Regional Road Network." 8th Regional Road Engineering Conference, Western Region, held in Batam, July 28-29, 2005.