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Research Article

Mapping of Land Use Suitability for Binjai City in 2020-2024 Using SPOT-6 Imagery

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ABSTRACT

Indonesia is a developing country that experiences high population growth every year. Population growth has an impact on the high demand for land use. Land use is often not in harmony with population growth, so land use does not align with regional spatial conditions. This study aims to determine land use in 2021 in Binjai City based on the 2020-2040 Regional Spatial Plan (RTRW) using Spot 6 imagery and determine the suitability of 2021 land use in Binjai City based on the 2020-2020 Regional Spatial Plan (RTRW) 2040 using Image Spot 6. This study is located in Binjai City, administratively flanked by two significant regencies: Langkat Regency and Deli Serdang Regency. The population of this research is the City of Binjai, with an area of 90.23 km^2. Data collection techniques are documentation study techniques, image interpretation, and field observations. Data analysis was carried out in a qualitative descriptive manner. The results of the study show that Land use in Binjai City in 2021 includes an agricultural area of 52.93 km^2 with a percentage of 58.66%, then a residential area of 33.85 km^2 with a percentage of 37.63%, area conservation has an area of 1.58 km^2 with a percentage of 1.75%, river bodies have an area of 0.90 km^2 with a percentage of 1%, local protected areas have an area of 0.38 km2 with a percentage of 0.39%, defense and security areas have an area of 0.45 km^2 with the percentage of 0.42%, industrial designation area of 0.12 km2 with a percentage of 0.15%, tourism area of 0.01 km^2 with a percentage of 0.01%, and lakes/situ area of 0.01% 0.01 km^2 with a percentage of 0.01%. The suitability of land use in 2021 with the Binjai City Spatial Plan (RTRW) for 2020-2040 is an area of 43.64 km^2 with a percentage of 48.36% which is suitable while that which is not suitable is 46, 59 km^2 with a percentage of 51.64%.

Keywords: Land Use; Land use suitability; Spatial Plan

INTRODUCTION

Agricultural, mining, and mineral management activities significantly impact the environment and natural resources (Singh et al., 2018). Basommi et al. (2016) stated that human-related land-use activities are important drivers of environmental change at different temporal scales. Land has an essential role in human life because the land is where all life activities take place, such as land use as a place to live and grow crops, as well as economic, social, and political activities (Bagheri et al., 2021). The form of land use carried out by humans is called land use (Saputra & Santosa, 2020). Various mapping techniques regarding land change and suitability

have been developed and applied in the last decades (Mishra et al., 2020). This is because changes regarding land use towards land suitability have become a significant issue in natural resource conservation policies and environmental monitoring (Tariq et al., 2021).

Land use suitability refers to how land is used by humans and their habitat, which emphasizes the functional role of land for economic activity (Liping et al., 2018). Land use is dynamic, and this is because it can always change over time and space. Mapping land use in urban areas is essential for effective urban management and planning due to rapid changes in urban processes (Huang et al., 2020). These changes are, of course, in line with the growth in population in one region (Adiyaksa & Djojomartono, 2020).

The rapid population growth and the increasing demands of the community's need for land have resulted in a discrepancy between land use and its allotment plan and can affect land value increases. In recent decades, the rapid migration of the population from villages to cities has resulted in changes in land use and suitability in urban areas (Li et al., 2016). Along with this, the growth of the urban population has also caused the distribution of settlements where people live to become unequal (Parry et al., 2018). Land suitability is essential for development studies, planning, and biological conservation. It is also beneficial in analyzing the natural and anthropogenic changes brought to the region over time (Mishra & Jabin, 2020).

Land suitability is a description of the suitability of a plot of land for a particular use (Taghizadeh-Mehrjardi et al., 2020), whereas land suitability analysis is a process carried out to determine the suitability of a specific area for the service under consideration. It expresses the concordance between a site regarding its intrinsic characteristics (match or mismatch) (Mugiyo et al., 2021). The concept of suitability for land use informs policymakers when deciding the economic and social consequences of land use (McDowell et al., 2018). Luan et al. (2021) stated that land use suitability assessment is an essential step in land use planning to support the development of urban areas. Land suitability evaluation provides an overview of information for planning regional development in the future (AL-Taani et al., 2021).

Land use and suitability are important driving factors in the global ecological constellation, especially in the agricultural sector which can be disrupted if not used appropriately (Molotoks et al., 2021). The various dynamics that occur, especially changes in land use, have even changed much of the landscape of the earth's surface. In addition, careless and inappropriate land use also significantly impacts ecosystem processes, biological cycles, biodiversity, development, and socio-economic sustainability (Malek & Verburg, 2020; Li et al., 2020; Hinz et al., 2020). On the other hand, FAO also defines land suitability evaluation as an assessment process that considers the performance of land for certain purposes. The assessment process identifies land use to best meet community needs. In addition, the assessment process can then determine land suitability for specific uses through a land suitability analysis that considers the nature of the land and user needs.

In recent times, the soil surface has been heavily degraded by humans. Intensive agriculture, mining, and urbanization are the main factors for land degradation (Awotwi et al., 2018). Therefore, it is necessary to conduct a study regarding the suitability of land use in an area to determine the appropriateness of land use in that area to increase land productivity (Mazahreh et al., 2019). In the context of land use, suitability determines the innate capacity of the land to perform a particular service with optimal efficiency and sustainability (Morales & de Vries, 2021).

Problems regarding land use and suitability are of serious concern to various parties. In this case, technology such as Geographic Information Systems and remote sensing is considered to be a solution to this problem. Inland suitability mapping and remote sensing integrates various sources of geospatial data, including satellite imagery, mapping data from drones, and ground network sensor data (Mansour et al., 2020). This data integration allows for a more holistic and accurate analysis of land characteristics, such as topography, water availability, and soil nutrient content. In addition, advances in information technology have encouraged the development of mobile and web-based GIS applications, enabling easier and faster access to information regarding sui (Xie et al., 2020). This application can be used by various stakeholders, including the government, to make more informed decisions based on the latest geospatial data. According to Abebe et al. (2022), mapping and calculating the status of changes in use through remote

sensing can identify vulnerable areas and design sustainable ecosystem services. Utilizing remote sensing data and geographic information systems is one of the essential techniques and tools to obtain spatial data related to land use and cover that is accurate, timely, efficient, and analyzes changes in the study area (Reis, 2008; Srivastava et al., 2018) as well as practical and cost-effective (Dubertret et al., 2022).

The results of the land suitability mapping are then described in map form using Geographic Information System (GIS) technology. This geographical information system has been widely applied in fields such as forestry, agriculture, and urban/regional spatial planning Fields (Rahmawaty et al., 2019). The images produced by SPOT 6 are known to have good quality, with little distortion and noise (Widyaningrum et al., 2021). This makes SPOT 6 imagery very suitable for high-precision and accuracy applications. As a study by Sulyantara et al. (2020), SPOT 6 high-resolution imagery is beneficial for regional spatial planning, monitoring, planning, and supervision in an area.

GIS technology can assist in mapping the suitability of residential land in Binjai City. GIS with overlays can unify all the base maps, which are the area's parameters for residential land use. Binjai, located in North Sumatra Province, Indonesia, has experienced rapid growth in recent decades (Laia et al., 2020). With population growth and rapid economic development, it is essential to understand how land in the city can be optimized for various purposes, such as housing, industry, agriculture, environmental conservation, and others. This research combines satellite mapping technology, geospatial analysis, and the latest data to develop land use suitability mapping that aligns more with the Regional Spatial Planning (RTRW) established by the city government. The purpose of this study is to be able to determine land use in 2021 in Binjai City based on the 2020-2040 Regional Spatial Plan (RTRW) using Spot 6 imagery and to determine the suitability of 2021 land use in Binjai City based on the 2021 Regional Spatial Plan (RTRW). 2020-2040.

METHODS

Study Area

This study was conducted in Binjai City (Figure 1), which is administratively flanked by two large regencies, namely Langkat Regency and Deli Serdang Regency, with an area of 90.23 km2 and astronomically located between 3°31'40"N - 3°40' 2" N and 98 °27'3"E – 98°32'32"E. The consideration of the researchers in choosing this location was seen from the aspect of land area, which relatively still has an impact on land use conditions due to high population growth in Binjai City and the establishment of Binjai City as a Medinding area, which encourages national scale growth resulting in increased land use requirements.

Research Methods

We used is a quantitative descriptive method with a spatial analysis approach with the help of a GIS (Geographic Information System) analysis tool using SPOT-6 Imagery. Spatial analysis is used to determine the existing conditions of settlements and identify area functions and land suitability in Binjai City.

Data Sources and Data Collection Techniques

The source of the data in this study was carried out using the Purposive Random Sampling technique (selected), namely taking selected samples that represent other land units. The characteristics of taking sample points are appropriate land use that does not follow the RTRW of Binjai City and can be reached to make it easier for researchers to carry out field surveys. In addition, research data was also obtained by conducting a documentation study to obtain secondary data such as spatial data in the form of Spot 2021 satellite imagery, administrative maps of Binjai City, and maps of Binjai City Spatial Planning.

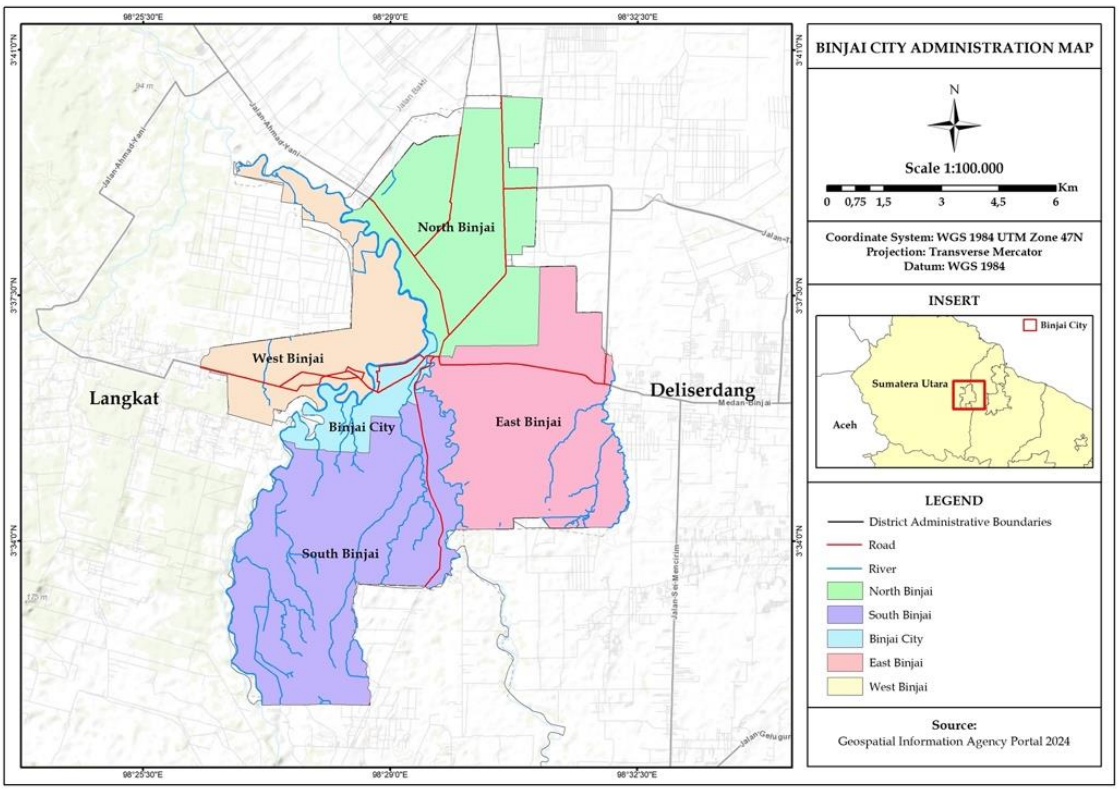

Figure 1. Study Area

Data Analysis

Data processing was carried out using the ArcGIS 10.8 application. In this research, the data that has been collected is then analyzed through several stages, including the following.

1. Cropping Area, in order to assess an area in more detail, we cropped an study area using ArcGIS 10.8.
2. Digitization, data analysis should be used digital format data, therefore raster data has been converted to digital format data.
3. Determining Conformity, the Map overlay process is carried out at this stage. Land use in 2021 in Binjai City based on the 2020-2040 Regional Spatial Plan (RTRW) using Spot 6 imagery and determining the suitability of 2021 land use in Binjai City based on the 2020-2040 Regional Spatial Plan (RTRW) obtained from digitized using ArcGIS software. For more details on the research method, see Figure 2 below.

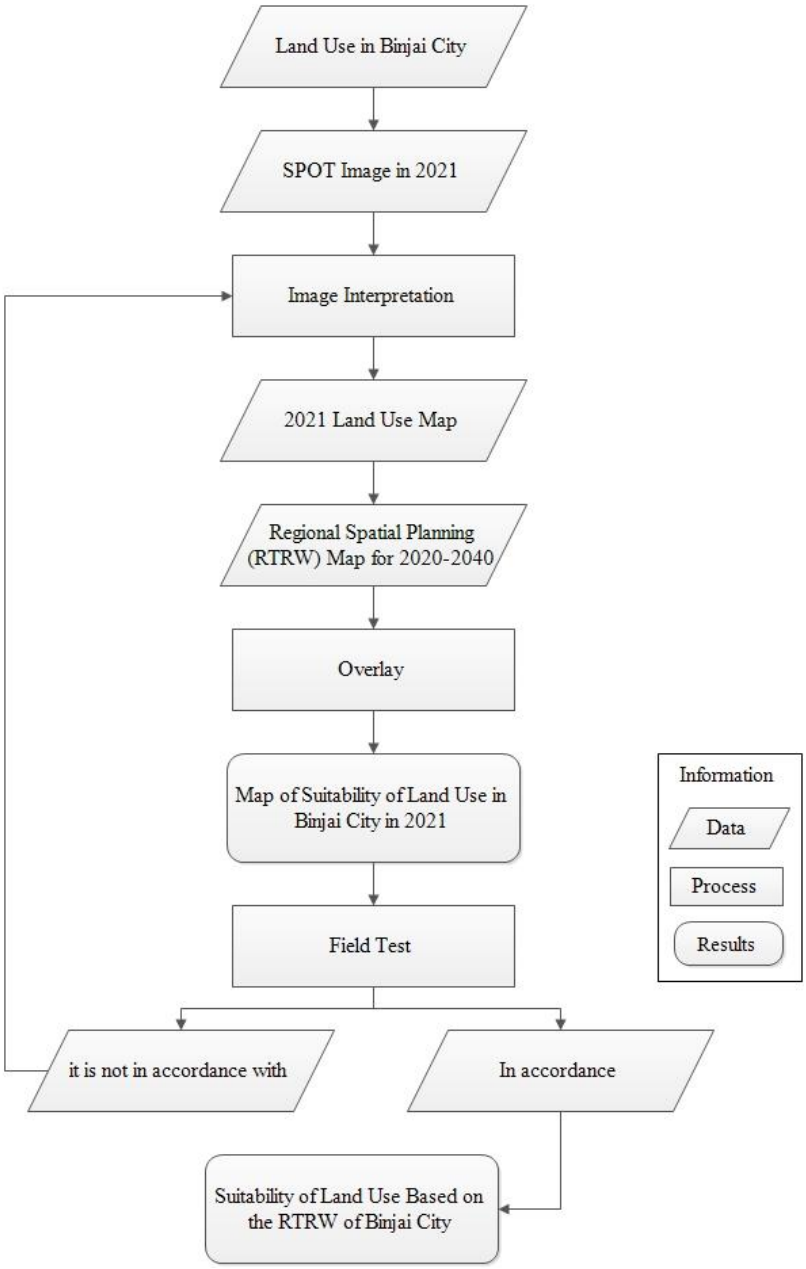

Figure 2. Research Framework

RESULTS AND DISCUSSION

Land Use in Binjai City in 2021

An analysis of land use in the City of Binjai in 2021 is carried out based on an analysis of its area by calculating the location of each area. This needs to be done because, based on 2018 BPS data, population growth in the Binjai City area has increased significantly, with the population growth rate reaching an average of 1.21% per year. The impact of population growth resulted in land use conditions changing to residential areas with a percentage change rate reaching 1% (Zevri et al, 2020). Land use analysis has many vital uses in urban planning, regional development, and environmental conservation. Land use management in urban areas is

necessary to reduce the surface runoff Field rate (Nurhamidah & Junaidi, 2018). Land use in 2021 in Binjai City is identified as having nine land use classifications according to the Regional Spatial Plan (RTRW) for the Binjai City area for 2020-2040. Land use areas are classified as river bodies, lakes/situ, conservation areas, tourism areas, local protected areas, residential areas, defense and security areas, agricultural areas, and industrial designated areas. The classification of land use in 2021 can be seen in Table 1.

Table 1. Land Use in Binjai City in 2021

No	Land Use	Wide (Km^2)	Percentage (%)
1	River Body	0.90	1
2	Lake	0.01	0.01
3	Conservation Areas	1.58	1.75
4	Tourism Area	0.01	0.01
5	Local Protected Areas	0.38	0.39
6	Residential Area	33.85	37.63
7	Defence and Security Area	0,.45	0.42
8	Agricultural area	52.93	58.66
9	Industrial Allotment Area	0.12	0.13
	Amount	90.23	100

Based on Table 1, the current land use in Binjai City covers an area of 90.23 km2 with land use dominance. The most extensive land use is an agricultural area of 52.93 km2, with a percentage of 58.66%. The farm area is dominated by rice, corn, soybeans, peanuts, green beans, cassava, and sweet potatoes (BPS, 2021). Utilization of space for residential areas with an area of 33.85 km2 with a ratio of 37.63%. The space allocation for this residential area has increased over the previous few years. This is supported by Laia et al. (2020) which stated in 2017, it was discovered that the residential area in Binjai City was 2,658.10 Ha or 29% of the total area of Binjai City. These residential areas are spread throughout all sub-districts, with the broadest being in North Binjai District, which is 787.71 Ha or 30% of the total settlement area in Binjai City, while the smallest is in Binjai Kota District, with an area of 230.14 Ha or only 9 % of the total residential area in Binjai City.

Utilization of space for a conservation area with an area of 1.58 km2 with a percentage of 1.75%. Utilization of room for the river body has an area of 0.90 km2 with a ratio of 1% and Space utilization for the local protected site has an area of 0.38 km2 with a percentage of 0.39%. The space utilization for the defense and security area is 0.45 km^2, with a ratio of 0.42%. The utilization of space as an area for industrial designation is 0.12 km^2 with a percentage of 0.15. In a previous study conducted by (Pinem, 2016), North Binjai District, Binjai City, was designated as the location of an industrial area in the RTRW of Binjai City for 2011 – 2030. The space utilization as a tourism area is 0.01 km2 with a ratio of 0.01%. The City of Binjai is a strategic city with great potential for the development of tourism business; even though the City of Binjai does not yet have natural tourism objects, the City of Binjai still has tourism potential that can be relied on, namely Culinary, Agro, Culture and History Tourism. The least space utilization in Binjai City in 2021 is a lake/situ area of 0.01 Km2 with a percentage of 0.01%.

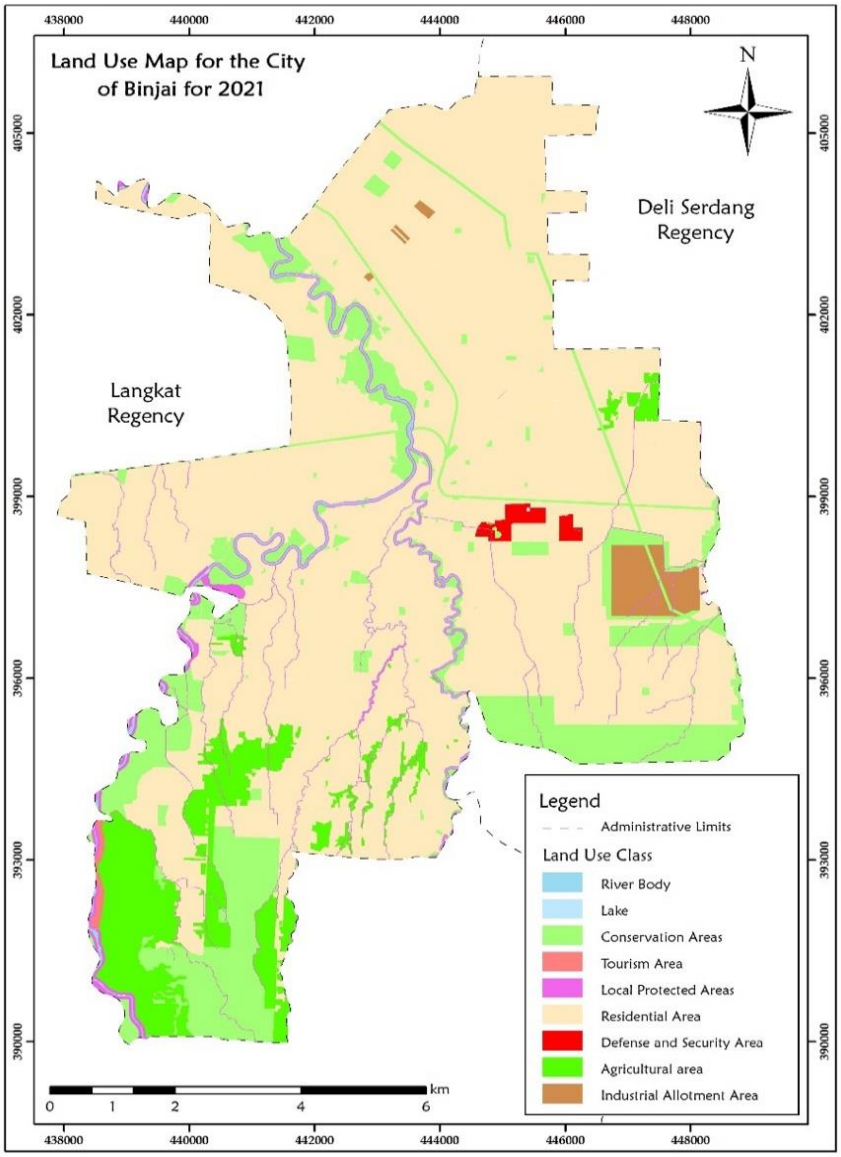

Figure 3. Land Use Map for the City of Binjai for 2021

Suitability of Land Use in 2021 Based on the Regional Spatial Plan (RTRW) for Binjai City for 2020-2040

The suitability of land use in 2021 for the Binjai City Spatial Plan (RTRW) for 2020-2040 is carried out by analyzing the results of the overlay between land use in 2021 and the Binjai City Spatial Plan for 2020-2040, carried out to determine the classification of land use that is suitable or not following The Binjai City Spatial Plan for 2020-2040 which is seen through the aspects of use/allocation, area, and location. The results of the suitability and incompatibility analysis of land use in 2021 with the Binjai City Spatial Plan for 2020-2040 can be seen in Table 2.

Table 2. Suitability of Land Use in 2021 with the RTRW of Binjai City Years 2020-2040

No	Classification of Allotment of Space	Land Use 2021 (km²)	Binjai City Spatial Year 2020-2040 (km²)	Suitable		Not Suitable	
				(km²)	(%)	(km²)	(%)
1	River Body	0.90	0.73	0.71	97.26	0.02	2.74
2	Lake	0.01	0.02	0.014	70	0.006	30
3	Conservation Areas	1.58	14.67	1.56	10.22	13.11	89.78
4	Tourism Area	0.01	0.16	0	0	0.16	100
5	Local Protected Areas	0.38	2.36	2.02	85.60	0.34	14.40
6	Residential Area	33.85	63.44	30.67	48.35	32.77	51.65
7	Defence and Security Area	0.45	0.45	0.45	100	0	0
8	Agricultural area	52.83	6.99	6.90	98.71	0.09	1.29
9	Industrial Allotment Area	0.12	1.41	1.32	93.62	0.09	6.38
	Amount	90.23	90.23	43.64	48.36	46.59	51.64

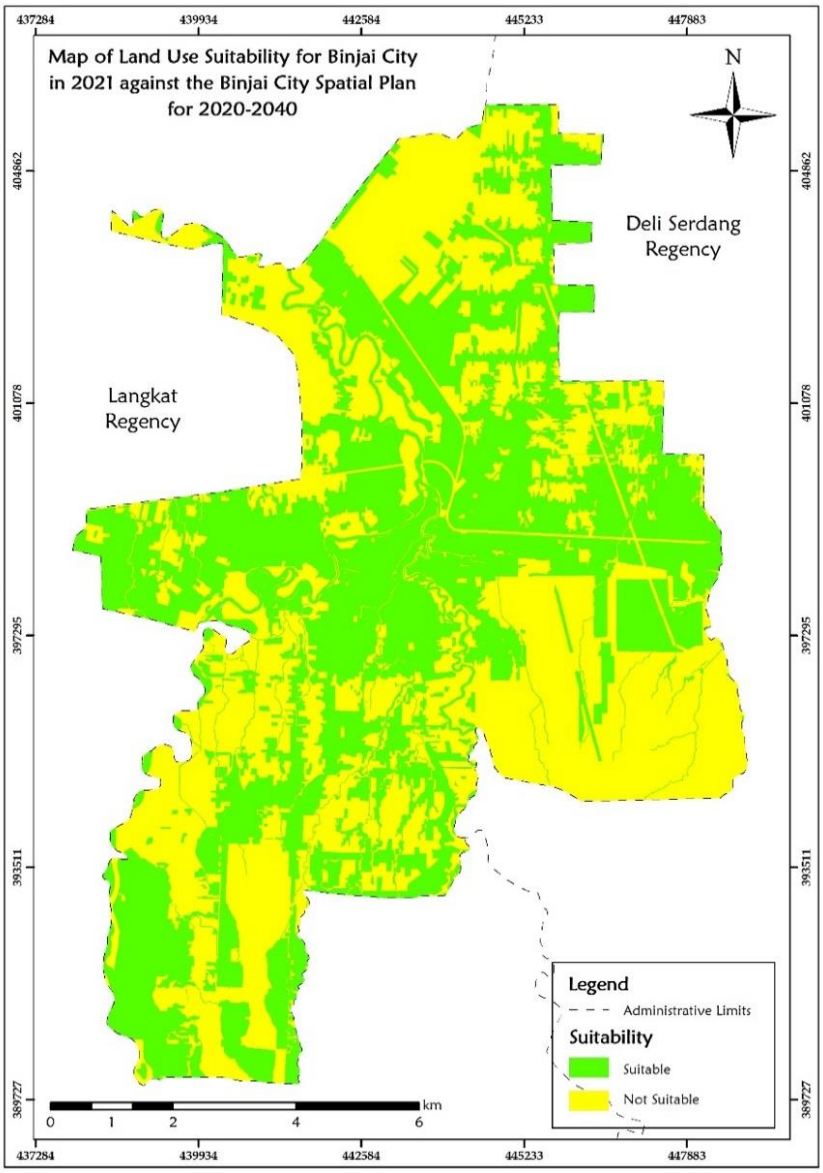

Figure 4. Map of Land Use Suitability for Binjai City in 2021 against the Binjai City Spatial Plan for 2020-2040

The area of each land use that is suitable and not following the Binjai City Spatial Plan (RTRW) for 2020-2040 is 43.64 km² with a percentage of 48.36%, which is practical, while that which is impractical or not suitable is 46.59 km² with a ratio of 51.64%. The land use suitability classification for the 2020-2040 Binjai City Spatial Planning, namely the use of river body land based on the Binjai City Spatial Plan, has an area of 0.71 km² and is not suitable for an area of 0.02 km2, the suitability of lake/situ land use based on the Binjai City Spatial Plan has an area of 0.014 km2 and unsuitable has an area of 0.006 km², land use suitability for conservation areas based on the RTRW of Binjai City has an area of 1.56 km² and problematic has an area of 13.11 km², suitability of land use for tourism based on the RTRW of Binjai City has an area of 0.16 km² and categorized as unsuitable, suitability for local protected area land use based on the RTRW of Binjai City has an area of 2.02 km² and problematic has an area of 0.34 km2. Based on the RTRW for Binjai City, land use suitability for regional agriculture has an area of 6.90 km² and is not suitable for 0.09 km². Land use suitability for industrial allotment areas based on the RTRW for Binjai City has an area of 1.32 km² and is not ideal for 0.09 km². Meanwhile, from the analysis results, the use of the area for defense and security rooms is the only space allotment following the Binjai City Spatial Plan for 2020-2040, which has an area of 0.45 km².

Accuracy Test

Based on the results of the research that has been carried out, the results of the land use map are carried out by an accuracy test to determine the level of accuracy of the resulting map. Accuracy test using confusion matrix table. The 2020-2040 Binjai City land suitability map has an Overall Accuracy of 81%. This level of accuracy was obtained based on the results of field checks and data processing. For more details on the accuracy test, see Table 3 below.

Table 3. Accuracy Test (Confusion Matrix)

RTWT	River Body	Lake	Conservation Areas	Tourism Area	Local Protected Areas	Residential Area	Defence and Security Area	Agricultural Area	Industrial Allotment Area	Total	Usser's Accuracy (%)	Error Omission
River Body	6	-	-	-	1	-	-	-	-	7	86%	14%
Lake	-	2	-	-	-	1	-	-	-	3	67%	33%
Conservation Areas	-	-	7	-	1	1	-	1	-	10	70%	30%
Tourism Area	-	-	-	-	-	-	-	1	-	1	-	100%
Local Protected Areas	-	-	-	-	6	1	-	-	-	7	86%	14%
Residential Area	-	-	-	-	1	12	-	1	1	15	80%	20%
Defence and Security Area	-	-	-	-	-	-	1	-	-	1	100%	-
Agricultural area	-	-	-	-	-	1	-	9	-	10	90%	10%
Industrial Allotment Area	-	-	-	-	-	1	-	-	7	8	88%	13%
Total	6	2	7	-	9	17	1	12	8	62		
Producer's Accuracy (%)	100 %	100 %	100%	-	67%	71%	100%	75%	88%	**Overall Accuracy (%)**		81%
Error Omission	-	-		-	33%	29%	-	25%	13%	**Kappa (%)**		78%

Land Conversion into Residential Areas in Binjai

Land in Binjai City is vulnerable to being converted into residential areas due to rapid population growth. Land use suitability for residential areas based on the RTRW of Binjai City has an area of 30.67 km², and is not ideal to have a place of 32.77 km². This needs to be done because, based on 2018 BPS data, population growth in the Binjai City area has increased significantly, with the population growth rate reaching an average of 1.21% per year. The impact of population growth resulted in land use conditions changing to residential areas with a percentage change

rate reaching 1% (Zaveri et al., 2020). Land use analysis has many important uses in urban planning, regional development, and environmental conservation. Land use management in urban areas is very necessary to reduce the rate of surface runoff.

The incompatibility of land use in Binjai City as a growing city is a problem that has been solved previously. This is in line with the study by Havara & Djoeffan (2022) which showed that the land designated as rice fields, forests, and other protected spaces in the city is slowly decreasing due to changes in its function to residential areas. This can threaten the sustainability of several city functions, such as a water catchment area, and cause various natural disasters. The consequences can have a negative impact if the construction is not by applicable policies and does not pay attention to environmental aspects.

The land conversion was carried out due to the increased need for community life support activities and the increased population. This is accompanied by other supporting developments so that the need for land or productive land rises yearly. Indirectly, land conversion makes land prices more expensive. Study by Sonyinderawan (2020) which showed that converting land into residential areas is often a major problem that impacts environmental damage and touches on issues related to human survival with massive development.

On the other hand, Binjai City has experienced large-scale land conversion into residential areas in recent years. Apart from rapid population growth, this condition is also supported by the designation of Binjai City as a Medinding area, which encourages national development. This encourages investment in large amounts of housing and residential land. These findings align with study by Purba & Idham (2021) which showed that land conversion to non-agriculture is increasingly widespread due to development policies that emphasize a growth perspective through ease of investment, both for local and foreign investors in providing land.

CONCLUSION

From the analysis that has been carried out on land use in Binjai City and the suitability of existing land use in Binjai City based on the 2020-2040 Regional Spatial Plan (RTRW) using Image Spot 6, it can be concluded that land use in Binjai City in 2021 is dominated by agricultural areas of 52, 93 Km^2 with a percentage of 58.66%, then a residential area of 33.85 km^2 with a ratio of 37.63%, a conservation area of 1.58 km^2 with a percentage ratio of 1.75%, a river body which has an area of 0.90 km2 with a ratio of 1%, locally protected areas have an area of 0.38 km^2 with a percentage of 0.39%, defense and security areas have an area of 0.45 km^2 with a percentage ratio of 0.42%, industrial designation areas with an area of 0.12 km^2 with a percentage of 0 .15%, a tourism area of 0.01 km^2 with a ratio of 0.01%, and finally a lake/situ area of 0.01 km^2 with a percentage ratio of 0.01%. From the results of an analysis of the suitability of land use in 2021 against the Binjai City Spatial Plan (RTRW) for 2020-2040, it was found that land use was suitable or not suitable, namely an area of 43.64 Km^2 with a percentage of 48.36% which was suitable while those that were impractical or not accordingly is 46.59 Km^2 with a ratio of 51.64 %.

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DECLARATIONS

Conflict of Interest

We declare no conflict of interest, financial or otherwise.

Ethical Approval

On behalf of all authors, the corresponding author states that the paper satisfies Ethical Standards conditions, no human participants, or animals are involved in the research.

Informed Consent
On behalf of all authors, the corresponding author states that no human participants are involved in the research and, therefore, informed consent is not required by them.

DATA AVAILABILITY

Data used to support the findings of this study are available from the corresponding author upon request.

REFERENCES

Abebe, G., Getachew, D., & Ewunetu, A. (2022). Analysing Land Use/Land Cover Changes and its dynamics using remote sensing and GIS in Gubalafito District, Northeastern Ethiopia. *SN Applied Sciences, 4*(1). https://doi.org/10.1007/s42452-021-04915-8

Adiyaksa, F., & Djojomartono, Ph.D., P. N. (2020). Evaluasi alih fungsi lahan pertanian menjadi lahan industri di Kabupaten Kendal Tahun 2014 - 2018. *JGISE: Journal of Geospatial Information Science and Engineering, 3*(1), 71. https://doi.org/10.22146/jgise.55519

AL-Taani, A., Al-husban, Y., & Farhan, I. (2021). Land suitability evaluation for agricultural use using GIS and remote sensing techniques: The case study of Ma'an Governorate, Jordan. *Egyptian Journal of Remote Sensing and Space Science, 24*(1), 109–117. https://doi.org/10.1016/j.ejrs.2020.01.001

Awotwi, A., Anornu, G. K., Quaye-Ballard, J. A., & Annor, T. (2018). Monitoring land use and land cover changes due to extensive gold mining, urban expansion, and agriculture in the Pra River Basin of Ghana, 1986–2025. *Land Degradation and Development, 29*(10), 3331–3343. https://doi.org/10.1002/ldr.3093

Bagheri, M., Ibrahim, Z. Z., Mansor, S., Manaf, L. A., Akhir, M. F., Talaat, W. I. A. W., & Beiranvand Pour, A. (2021). Land-use suitability assessment using delphi and analytical hierarchy process (D-ahp) hybrid model for coastal city management: Kuala terengganu, peninsular malaysia. *ISPRS International Journal of Geo-Information, 10*(9). https://doi.org/10.3390/ijgi10090621

Basommi, L. P., Guan, Q. F., Cheng, D. D., & Singh, S. K. (2016). Dynamics of land use change in a mining area: a case study of Nadowli District, Ghana. *Journal of mountain science, 13*, 633-642. https://doi.org/10.1007/s11629-015-3706-4

BPS (2021). *Kota Binjai dalam Angka*. Badan Pusat Statistik.

Dubertret, F., Tourneau, F. M. Le, Villarreal, M. L., & Norman, L. M. (2022). Monitoring Annual Land Use/Land Cover Change in the Tucson Metropolitan Area with Google Earth Engine (1986–2020). *Remote Sensing, 14*(9), 1–22. https://doi.org/10.3390/rs14092127

Havara, S. A., & Djoeffan, S. H. (2022). Peremajaan kawasan permukiman dengan pendekatan ekologi berkelanjutan. *Jurnal Riset Perencanaan Wilayah Dan Kota*, *2*(2) 129–138. https://doi.org/10.29313/jrpwk.v2i2.1314

Hinz, R., Sulser, T. B., Huefner, R., Mason-D'Croz, D., Dunston, S., Nautiyal, S., Ringler, C., Schuengel, J., Tikhile, P., Wimmer, F., & Schaldach, R. (2020). Agricultural development and land use change in India: A Scenario analysis of trade-offs between UN Sustainable Development Goals (SDGs). *Earth's Future, 8*(2), 1–19. https://doi.org/10.1029/2019EF001287

Huang, Z., Qi, H., Kang, C., Su, Y., & Liu, Y. (2020). An ensemble learning approach for urban land use mapping based on remote sensing imagery and social sensing data. *Remote Sensing, 12*(19), 1–18. https://doi.org/10.3390/rs12193254

Laia, G., Nasution, Z., & Toha, A. S. (2020). Analisis kesesuaian lahan permukiman menggunakan Sistem Informasi Geografis Di Kota Binjai. *Jurnal Serambi Engineering, 5*(2), 921–932. https://doi.org/10.32672/jse.v5i2.1919

Li, K., Feng, M., Biswas, A., Su, H., Niu, Y., & Cao, J. (2020). Driving factors and future prediction of land use and cover change based on satellite remote sensing data by the LCM model: A case study from gansu province, China. *Sensors (Switzerland), 20*(10). https://doi.org/10.3390/s20102757

Li, L., Lu, D., & Kuang, W. (2016). Examining urban impervious surface distribution and its dynamic change in Hangzhou metropolis. *Remote Sensing, 8*(3), 19–24. https://doi.org/10.3390/rs8030265

Liping, C., Yujun, S., & Saeed, S. (2018). Monitoring and predicting land use and land cover changes using remote sensing and GIS techniques—A case study of a hilly area, Jiangle, China. *PLoS ONE, 13*(7), 1–23. https://doi.org/10.1371/journal.pone.0200493

Luan, C., Liu, R., & Peng, S. (2021). Land-use suitability assessment for urban development using a GIS-based soft computing approach: A case study of Ili Valley, China. *Ecological Indicators, 123*, 107333. https://doi.org/10.1016/j.ecolind.2020.107333

Malek, Ž., & Verburg, P. H. (2020). Mapping Global Patterns of Land Use Decision-Making. *Global Environmental Change, 65*, 102170. https://doi.org/10.1016/j.gloenvcha.2020.102170

Mansour, S., Al-Belushi, M., & Al-Awadhi, T. (2020). Monitoring Land Use and Land Cover Changes in the Mountainous Cities of Oman Using GIS and CA-Markov Modelling Techniques. *Land Use Policy, 91*, 104414. https://doi.org/10.1016/j.landusepol.2019.104414

Mazahreh, S., Bsoul, M., & Hamoor, D. A. (2019). GIS approach for assessment of land suitability for different land use alternatives in semi arid environment in Jordan: Case study (Al Gadeer Alabyad-Mafraq). *Information Processing in Agriculture, 6*(1), 91–108. https://doi.org/10.1016/j.inpa.2018.08.004

McDowell, R. W., Snelder, T., Harris, S., Lilburne, L., Larned, S. T., Scarsbrook, M., Curtis, A., Holgate, B., Phillips, J., & Taylor, K. (2018). The land use suitability concept: Introduction and an application of the concept to inform sustainable productivity within environmental constraints. *Ecological Indicators, 91*, 212–219. https://doi.org/10.1016/j.ecolind.2018.03.067

Mishra, P. K., Rai, A., & Rai, S. C. (2020). Land use and land cover change detection using geospatial techniques in the Sikkim Himalaya, India. *Egyptian Journal of Remote Sensing and Space Science, 23*(2), 133–143. https://doi.org/10.1016/j.ejrs.2019.02.001

Mishra, S., & Jabin, S. (2020). Land Use Land Cover Change Detection using LANDSAT images: A Case Study. *2020 IEEE 5th International Conference on Computing Communication and Automation, ICCCA 2020*, 730–735. https://doi.org/10.1109/ICCCA49541.2020.9250801

Molotoks, A., Smith, P., & Dawson, T. P. (2021). Impacts of Land Use, Population, and Climate Change on Global Food Security. *Food and Energy Security, 10*(1), 1–20. https://doi.org/10.1002/fes3.261

Morales, F., & de Vries, W. (2021). Establishment of land use suitability mapping criteria using Analytic Hierarchy Process (AHP) with Practitioners and Beneficiaries. *Land, 10*(3), 235. https://doi.org/10.3390/land10030235

Mugiyo, H., Chimonyo, V. G. P., Sibanda, M., Kunz, R., Masemola, C. R., Modi, A. T., & Mabhaudhi, T. (2021). Evaluation of land suitability methods with reference to neglected and underutilised crop species: A scoping review. *Land, 10*(2), 1–24. https://doi.org/10.3390/land10020125

Nurhamidah, N., Junaidi, A., & Kurniawan, M. (2018). Tinjauan perubahan tata guna lahan terhadap limpasan permukaan. Kasus: DAS Batang Arau Padang. *Jurnal Rekayasa Sipil, 14*(2), 131-138. https://doi.org/10.25077/jrs.14.2.131-138.2018

Parry, J. A., Ganaie, S. A., & Sultan Bhat, M. (2018). GIS based land suitability analysis using AHP model for urban services planning in Srinagar and Jammu urban centers of J&K, India. *Journal of Urban Management, 7*(2), 46–56. https://doi.org/10.1016/j.jum.2018.05.002

Pinem, D. E. (2016). Menemukan strategi pengembangan kawasan industri melalui analisis sektor unggulan Kota Binjai. *Jurnal Wilayah dan Lingkungan, 4*(1), 45-64.

Purba, M. S., & Idham, I. (2021). Analisis hukum alih fungsi tanah pertanian menjadi pembangunan pemukiman dan perumahan. *ARBITER: Jurnal Ilmiah Magister Hukum, 3*(2), 151–161. https://doi.org/10.31289/arbiter.v3i2.636

Rahmawaty, R., Rauf, A., & Frastika, S. (2019). Mapping of actual and potential land suitability for oil palm in several land unit using geographic information system. *IOP Conference Series: Earth and Environmental Science, 260*(1). https://doi.org/10.1088/1755-1315/260/1/012073

Reis, S. (2008). Analyzing land use/land cover changes using remote sensing and GIS in Rize, North-East Turkey. *Sensors, 8*(10), 6188–6202. https://doi.org/10.3390/s8106188

Saputra, V. A., & Santosa, P. B. (2020). Analisis geospasial perubahan penggunaan lahan dan kesesuaiannya terhadap RTRW Kabupaten Purworejo Tahun 2011-2031. *JGISE: Journal of Geospatial Information Science and Engineering, 3*(2), 152. https://doi.org/10.22146/jgise.60931

Sejati, A. E., Hasan, M., Nursalam, L. O., Harianto, E., & Deris, D. (2020). Kesesuaian pemetaan penggunaan lahan pemukiman dengan kondisi sebenarnya di Kecamatan Katobu Dan Kecamatan Duruka Kabupaten Muna. *Tunas Geografi, 9*(1), 55. https://doi.org/10.24114/tgeo.v9i1.17732

Singh, S. K., Laari, P. B., Mustak, S., Srivastava, P. K., & Szabó, S. (2018). Modelling of land use land cover change using earth observation data-sets of Tons River Basin, Madhya Pradesh, India. *Geocarto International, 33*(11), 1202–1222. https://doi.org/10.1080/10106049.2017.1343390

Sonyinderawan, F. (2020). Dampak alih fungsi lahan sawah menjadi non pertanian mengakibatkan ancaman degradasi lingkungan. *JURNAL SWARNABHUMI : Jurnal Geografi Dan Pembelajaran Geografi, 5*(2), 36. https://doi.org/10.31851/swarnabhumi.v5i2.4741

Sulyantara, D. H., Ulfa, K., Brahmantara, R. P., Siwi, S. E., Prabowo, Y., & Rangkuti, C. (2020). Pengembangan mosaik data Spot 6/7 menggunakan metode tile based berdasarkan haze index. *Media Komunikasi Geografi, 21*(1), 40-51.

Chetia, S., Borkotoky, K., Medhi, S., Dutta, P., & Basumatary, M. (2020). Land use land cover monitoring and change detection of Tinsukia, India. *International Journal of Innovative Technology and Exploring Engineering, 9*(6), 502-507. https://doi.org/10.35940/ijitee.f3814.049620

Srivastava, P. K., Singh, S. K., Gupta, M., Thakur, J. K., & Mukherjee, S. (2018). Modeling impact of land use change trajectories on groundwater quality using remote sensing and GIS. *Environmental Engineering and Management Journal, 12*(12), 2343–2355. https://doi.org/10.30638/eemj.2013.287

Taghizadeh-Mehrjardi, R., Nabiollahi, K., Rasoli, L., Kerry, R., & Scholten, T. (2020). Land suitability assessment and agricultural production sustainability using machine learning models. *Agronomy, 10*(4), 1–20. https://doi.org/10.3390/agronomy10040573

Tariq, A., Shu, H., Siddiqui, S., Imran, M., & Farhan, M. (2021). Monitoring land use and land cover changes using geospatial techniques, a case study of Fateh Jang, Attock, Pakistan. *Geography, Environment, Sustainability, 14*(1), 41–52. https://doi.org/10.24057/2071-9388-2020-117

Widyaningrum, E., Perdana, A. P., Andari, R., Mayasari, R., & Damayanti, A. P. (2021). Penggunaan citra satelit dan kompilasi data keruangan untuk pemutakhiran peta dasar skala menengah seluruh Indonesia. *Elipsoida: Jurnal Geodesi dan Geomatika, 4*(2), 100-108. https://doi.org/10.14710/elipsoida.2021.13874

Xie, H., He, Y., Choi, Y., Chen, Q., & Cheng, H. (2020). Warning of negative effects of land-use changes on ecological security based on GIS. *Science of the Total Environment, 704*, 135427. https://doi.org/10.1016/j.scitotenv.2019.135427

Zaveri, E., Russ, J., & Damania, R. (2020). Rainfall anomalies are a significant driver of cropland expansion. *Proceedings of the National Academy of Sciences, 117*(19), 10225-10233. https://doi.org/10.1073/pnas.1910719117