Integrating Spatial Utilization and Sustainability Indicators for Residential Area Planning in Kediri Regency

Edi Rusdiyanto[1], Abdillah Munawir[2]

[1]Program Studi Magister Ilmu Lingkungan Universitas Terbuka, Tangerang Selatan, INDONESIA
[2]Sekolah Tinggi Ilmu Hayati Institut Teknologi Bandung, Bandung, INDONESIA

E-mail: abdillah.munawir@itb.ac.id

| Submitted: April 08, 2026 | Revised: May 16, 2026 | Accepted: May 22, 2026 |

| Published: May 29, 2026 |

ABSTRACT

The aim of this study is to analyze the current condition of land use within the context of spatial utilization in Kediri Regency, as well as to formulate policy directions for land management through a sustainable land-use change transition matrix analysis. The analytical method employed in this study involves spatial-temporal interpretation using a Geographic Information System (GIS), utilizing Landsat-7 ETM, Landsat-8 OLI imagery, and Google Earth data, combined with a mixed-method approach. The results of the spatial analysis indicate that forest land has experienced a consistent decline over time. In 2008, the forest area was 5,363 hectares; in 2013, it decreased to 5,241 hectares; in 2018, it further declined to 5,035 hectares; and by 2023, it was recorded at 4,906 hectares. In contrast, built-up land has shown a steady increase, reflecting rising urbanization in Kediri Regency and indicating growing environmental pressure due to forest reduction. In 2008, the built-up area covered 25,698 hectares; in 2013, it increased to 26,762 hectares; in 2018, it rose again to 27,955 hectares; and by 2023, it significantly expanded to 30,749 hectares. The dynamics of land-use change in Kediri Regency during the 2008–2023 period reflect a significant transformation from an agrarian character toward an increasingly urbanized area. Spatial analysis highlights the rapid expansion of built-up land as the dominant phenomenon, driven by population growth, urbanization, and regional economic development. Therefore, sustainable spatial planning policies are needed through the integration of spatial and temporal data, control of land-use conversion, and adaptive policy-making to maintain a balance between economic development, environmental sustainability, and long term societal well being.

Keywords: Kediri, spatial analysis, land use, forest, Built-Up.

INTRODUCTION

Changes in land cover are basically inseparable from the dynamics of economic growth and population growth which tends to increase significantly in Indonesia [1]. Uncontrolled population growth drives the need for greater space for settlements, infrastructure, and other economic activities, thus triggering intensive land use transformation [2], [3]. These fluctuating conditions contribute to the emergence and development of new areas that serve as centers of economic activity. Regional development is generally characterized by the expansion of the economic and service sectors, as well as increased availability of public service facilities such as education, trade, and industry [4]. Therefore, regions experiencing accelerated development often become magnets for investment and business activity, which ultimately strengthens their role as new growth centers [5].

Along with the increasing population and development activities, the demand for land has also experienced a significant increase [6]. On the other hand, the availability of land is basically limited and relatively fixed, although the quality of its use can be improved through technological innovation and better planning [7], [8]. The imbalance between land needs and availability drives the expansion of built-up land, which often sacrifices productive land such as agriculture and plantations. As a result, land use conflicts become increasingly frequent, especially in areas experiencing high development pressure [9], [10]. This phenomenon shows the urgent need for more planned and sustainable space management [11], [12].

Kediri Regency is one of the areas experiencing quite rapid territorial development. This is indicated by the development of areas with the phenomenon of conurbation, where the outskirts of Kediri

pISSN 2302-4240
eISSN 2655-2086
Volume 15, Issue 2, June 2026, pp.0690-0698
DOI: http://dx.doi.org/10.32832/astonjadro.v15i2.23208 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Regency, such as Ngasem and Gampengrejo Districts, are starting to functionally merge with the City of Kediri, forming a new urban agglomeration. [13], [14], [15]. The development of the Simpang Lima Gumul area began in 2002 [16], [17]. The existence of the Simpang Lima Gumul CBD area, Dhoho International Airport, the planned construction of toll roads, and the phenomenon of conurbation trigger economic sector development, caused by the infrastructure built to support the area becoming an attraction for the surrounding community to visit and also an attraction for entrepreneurs/investors to invest [18], [19], [20].

Kediri Regency has experienced a continuously increasing population growth from year to year. This population increase has also led to a growing demand for buildings. Not only residential buildings for living, but also other infrastructure that supports the community, such as schools, offices, hospitals, and highways. In 2011, the population of Kediri Regency was 1,576,160 people, and over the last 10 years, by 2022, it increased to 1,644,400 people, an increase of 68,240 people with a population growth rate of 1.2% per year [21]. With the development of construction and the increasing population in Kediri Regency, the land needed for non-agricultural activities such as residential areas, trade, and industry is increasing. This often causes conflicts in land use. Land conversion tends to be unavoidable; therefore, an integrative planning is required, primarily for sustainable development interests by combining a planning for the management of changes in built-up land cover with an approach considering social, ecological, and economic dimensions [22], [23]. Thus, in the implementation of this research, an approach of mapping and satellite image interpretation (USGS) will be used along with environmental sustainability analysis. The integration of this method is expected to provide a comprehensive picture of land cover changes as well as their implications for regional sustainability [24]. Furthermore, the use of a spatial approach combined with sustainability analysis provides an important contribution to the regional planning process. The analysis results can not only be used to identify land use change patterns but also to formulate more effective and sustainable spatial management strategies. This is very important for Kediri Regency, which is experiencing considerable development pressure, making it necessary to have policies that can direct optimal land use without neglecting environmental aspects.

Based on this background, this study aims to analyze the actual conditions of land use in the context of spatial utilization in Kediri Regency, as well as to formulate land management policy directions using a transition matrix analysis of sustainable land use change. The main contribution of this study lies in developing a study of land cover change by integrating spatial analysis and regional growth dynamics. This approach allows for a clearer identification of the relationship between land cover change and regional economic expansion. Furthermore, this study offers a more comprehensive perspective by combining various indicators, such as population growth, infrastructure development, and economic sector expansion, to explain the overall pattern of regional transformation. Therefore, the results of this study are expected to make a significant contribution to both the development of science and the practice of sustainable regional development planning.

RESEARCH METHODS

Study Area

In general, this research was conducted in Kediri Regency, East Java Province. This location was chosen to study and analyze land cover changes as well as social sustainability and ecological conditions in the management of development and regional sustainability in Kediri Regency. The research was carried out over 8 (eight) months, from May 2023 to December 2023. Geographically, Kediri Regency is located between 111° 47' 05" and 112° 18' 20" East Longitude and 7° 36' 12" to 8° 0' 32" South Latitude. This 1,386.05 km² area is dominated by lowlands and fertile mountains divided by the Brantas River, and is bordered by five regencies (Nganjuk, Jombang, Malang, Blitar, and Tulungagung) with a tropical climate.

Analytcal Method

This research uses satellite imagery data with high spatial-temporal resolution, with data collection using the Google Earth Pro application in 2023 and the USGS Earth Explorer website to download Landsat-7 ETM+ data from 2008 and Landsat-8 OLI data from 2013, 2018, and 2023. The 2023 High-Resolution Satellite Imagery from Google Earth Pro was chosen to carry out the delineation

process of Kediri Regency, while the time span for Landsat 8 Level 1 data was chosen due to the availability of imagery data with the least cloud cover on USGS EarthExplorer. In addition, the specified time period allows for monitoring significant changes in land use in the area. The data used can provide a visualization of land use changes as well as identify the types of land use that have changed in the research area. The collected data will be analyzed and further processed to understand changes in land use due to increased development in Kediri Regency. The conditions and impacts of changes in land use are known based on the results of interviews with 35 respondents from academics, community leaders, and several government officials. The remote sensing analysis data is then classified and changes in each land cover are calculated using spatial analysis techniques. The spatial analysis referred to in this study involves the presentation of land change analysis results and spatial statistics [25]. Atmospheric factors that need to be corrected include errors in surface reflection or Earth's curvature, sunlight direction, weather conditions, atmospheric conditions, and other factors so that the information provided is more accurate [26]. The distribution of social, economic, and ecological impacts in Kediri Regency in 2008, 2013, 2018, and 2023 was analyzed through several stages, namely: image processing analysis using remote sensing techniques, geometric correction, Supervised Classification, Ground check, up to validation (overall and kappa accuracy), as well as sustainability analysis.

Table 1. Data Review of Research Analysis in Kediri Regency

Data	Acquisition Data	Source Data	Method	Scale resolusi
Citra Landsat-7ETM+ and Landsat-8 OLI/TIRS Level 1	Recording 2008, 2013, 2018 and 2023	United StatesGeological Survey (USGS)	Spatial and Statistical Analysis	30 m
RBI Kediri Regency	27 December 2022	Ina-Geoportal	Overlay	1 : 25.000
Sustainability of the Kediri Regency Area	Survei, Ground Checkh Point 2023	Interview	Mix Method	-

RESULT AND DISCUSSION

Spatial Analysis of Social, Economic, and Ecological Areas

Kediri Regency currently shows a fairly rapid regional development dynamic as part of the regional system in East Java, especially in its relation to Kediri City as a center of economic and service activities. Socially, population growth continues to increase along with the urbanization process that drives the shift of community structure from agrarian to non-agrarian sectors [27]. The population distribution is still dominated by rural areas, but peri-urban areas are experiencing significant growth due to the expansion of built-up areas [28]. This condition causes changes in social interaction patterns, increased societal heterogeneity, and the emergence of challenges in providing basic services such as education, health, and residential infrastructure. Economically, Kediri Regency still relies on the agricultural sector as the main basis, especially rice, sugarcane, and horticultural commodities, although the contribution of the industrial and trade sectors is increasingly growing. Nevertheless, this economic growth is also accompanied by an increase in the conversion of agricultural land into residential and industrial areas, which has the potential to threaten local food security. From an ecological aspect, the environmental conditions in Kediri Regency face quite significant pressure due to uncontrolled land use changes. The illustration of the research area for data measurement is presented in Figure 1 below.

ASTONJADRO
pISSN 2302-4240
eISSN 2655-2086
Volume 15, Issue 2, June 2026, pp.0690-0698
DOI: http://dx.doi.org/10.32832/astonjadro.v15i2.23208 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Figure 1. Location of the Kediri Area Interview and Ground Check Point

The results of the interviews show that all respondents consistently highlighted that threats to land sustainability are the main issue that needs to be addressed immediately. Pressure from land conversion, residential growth, and economic activities are considered to be increasingly reducing the area and quality of productive land. In addition, respondents also expressed concerns about the decline in environmental carrying capacity, which impacts food security and ecosystem balance. Therefore, efforts for more sustainable and integrated land management are needed to maintain a balance between development needs and environmental preservation.

The spatial analysis presents land use transformations in Kediri Regency during the periods of 2008, 2013, 2018, and 2023. The most striking phenomenon is the massive expansion of built-up areas, marked by a significant spread from the center to the east and north. This indicates a high rate of urbanization, where the need for housing and infrastructure is increasing rapidly in line with population growth and regional economic development. Conversely, there is degradation of natural vegetation cover. Forests and plantations appear to be shrinking and fragmenting, being converted to agricultural land or directly into residential areas. Dry agricultural land and rice paddies are also under pressure due to land conversion, although they remain dominant in some areas. Overall, these dynamics indicate a shift in the characteristics of Kediri Regency from a predominantly agricultural and natural region to a more urbanized one. If this trend continues without strict spatial planning, the balance of the ecosystem and the availability of productive land in the future could be threatened.

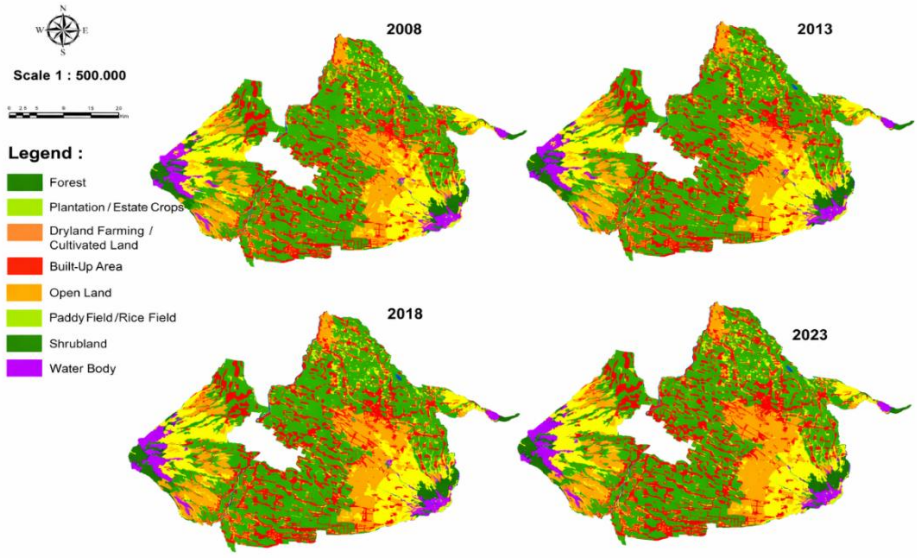
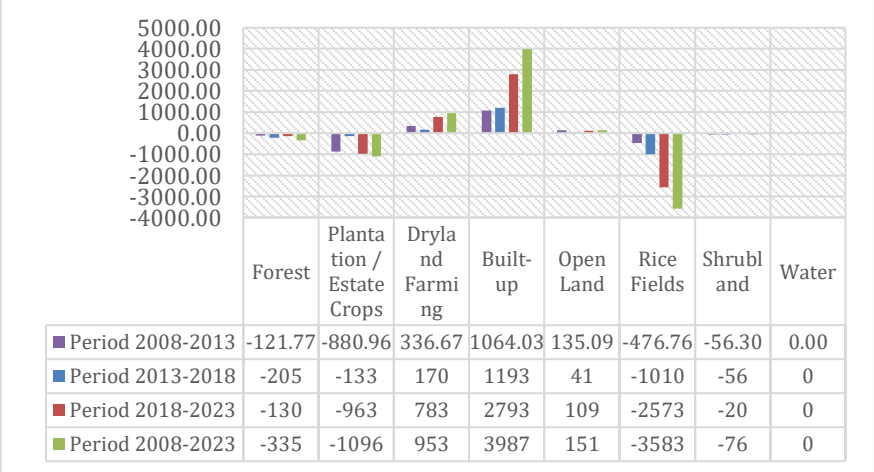


Figure 2. Distribution of land use changes in 2008, 2013, 2018, and 2023

Based on Figure 2, data on land use change from 2008 to 2023 are presented. The data is divided into several land uses. Forest land use has decreased year by year. In 2008, forest area was 5,363 ha, in 2013 it was 5,241 ha, in 2018 it decreased again to 5,035 ha, and in 2023 the forest area was recorded at 4,906 ha. This indicates a trend of forest decline, which, based on community interviews, is caused by human activities. The area of gardens or plantations was known to be 25,333 ha in 2008, slightly decreasing to 24,452 ha in 2013. In 2018 it decreased again to 24,319 ha, and in 2023 the area became 23,356 ha. These changes indicate territorial dynamics. The increase in built-up land shows rising urbanization in Kediri Regency, while the decrease in forests indicates pressure on the environment. In 2008, the built-up area was 25,698 ha; in 2013, it increased to 26,762 ha; in 2018, it rose again to 27,955 ha; and in 2023, it significantly increased to 30,749 ha. This phenomenon aligns with research [29], which explains that global urban expansion will continue to convert agricultural land and vegetation into built-up areas in the coming decades. The decline of rice fields can impact food security, where the increase in fields indicates a shift in agricultural activities. This data is important for regional planning so that spatial analysis can be used to understand the patterns of area changes in Kediri Regency. The use of satellite imagery can help validate the data, so that these changes can determine the influence of economic factors. Social factors also play a role in land changes; on one hand, government policies can affect decisions regarding the sustainability of the community and long-term climate change, which can also have significant impacts. Therefore, good management with regular monitoring is very important. The integration of spatial and temporal data is very important, with accurate results helping decision-making.

Overall, these results are in line with several studies, [30], It shows that the loss of global forest cover is largely driven by human activities such as agricultural expansion and urbanization. The increase in built-up land in Kediri reflects the urbanization process that reinforces pressure on the environment, as also found in the study [31], which indicates a strong relationship between economic growth, urbanization, and land cover changes based on global satellite imagery. In addition, the decline in rice fields followed by an increase in dry fields indicates a transformation in the agricultural system that could affect food security, a phenomenon also discussed by [32], which states that changes in global agricultural land use are influenced by population pressure, market, and policy, which ultimately affect food production. The socio-economic factors and policies mentioned in the data also align with research [33], which emphasizes that changes in land use are the result of a complex interaction between human factors (economic, policy, social) and biophysical factors. The Distribution of Land Use Change Per-Periodic in Kediri Regency area are presented in Figure 3.



	Forest	Plantation / Estate Crops	Dryland Farming	Built-up	Open Land	Rice Fields	Shrubland	Water
Period 2008-2013	-121.77	-880.96	336.67	1064.03	135.09	-476.76	-56.30	0.00
Period 2013-2018	-205	-133	170	1193	41	-1010	-56	0
Period 2018-2023	-130	-963	783	2793	109	-2573	-20	0
Period 2008-2023	-335	-1096	953	3987	151	-3583	-76	0

Figure 3. Distribution of Land Use Change Per-Period in Kediri Regency.

pISSN 2302-4240
eISSN 2655-2086
Volume 15, Issue 2, June 2026, pp.0690-0698
DOI: http://dx.doi.org/10.32832/astonjadro.v15i2.23208 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Figure 3 shows the changes in land use across several categories during the periods 2008–2013, 2013–2018, 2018–2023, as well as the cumulative period 2008–2023 in Kediri Regency. In general, there is a noticeable dynamic among natural land, agricultural land, and built-up land. In the forest category, a decrease occurred in all periods, with a total reduction of around -335 ha during 2008–2023, indicating pressure on forest areas. In the plantation category, there was also a fairly large decrease, especially in the 2018–2023 period, so that the total decrease reached around -1,096 ha. In contrast, the fields or dryland farming category experienced a consistent increase in each period, with a total increase of about 953 ha, indicating a shift in agricultural land use patterns. The most striking changes occurred in built-up land, which increased significantly in all periods, with a total rise of about 3,987 ha, reflecting the rapid development of urbanization and infrastructure. Open land also saw an increase, although relatively small. Meanwhile, rice fields showed a very sharp decline, especially in the 2018–2023 period, with a total decrease of around -3,583 ha, which could potentially impact food security. The shrub category experienced a slight decrease, while water bodies relatively did not change. Overall, this graph shows the conversion of land from the agricultural sector and natural vegetation to built-up land, which is closely related to population growth and regional economic activities.

Table 2. Land Use Change Transition Matrix for the Period 2008-2023.

Landuse 2008	**Landuse 2023**								**Total**
	Forest	Plantation	Dryland Farming	Built Up	Open Land	Rice Fields	Shrubland	Water	
Forest	4,906	132	213				112		5,363
Plantation		22,452	1,799	972			110		25,333
Drland Farming		356	21,522	166	289		53		22,385
Built Up				25,698					25,698
Open Land				36	818				854
Rice Fields		114	68	3,877		62,241			66,300
Shrubland		303	72		33		4,976		5,383
Water								776	776
Total	**4,906**	**23,356**	**23,675**	**30,749**	**1,140**	**62,241**	**5,251**	**776**	**152,092**

In Table 2, the land use transition matrix for the 2008–2023 period in Kediri Regency shows the direction of changes from each land class at the beginning of 2008 to the condition in 2023. The diagonal values in the matrix represent the area of land that remains in the same category, for example, forest that remains forest at 4,906 ha, plantation that remains at 22,452 ha, and rice fields that remain at 62,241 ha, indicating stability in some land uses. However, there are also quite significant changes between categories. Forest land was converted into farmland by 213 ha and into plantations by 132 ha, indicating pressure on forest areas. Plantations largely changed into farmland (1,799 ha) and built-up land (972 ha), reflecting economic dynamics and space needs. Farmland also experienced changes into forest (356 ha) and built-up land (166 ha), although most of it remained as farmland. The most significant change is seen in rice fields, which have transformed into built-up areas covering 3,877 hectares, indicating a large-scale conversion of productive agricultural land into development zones. In addition, shrublands have also transitioned into several categories such as forests and farmland. A small portion of open land has changed into built-up areas. Meanwhile, water bodies remain relatively stable without significant changes. Overall, this matrix shows that the conversion to built-up land has become the dominant trend, which has implications for changes in regional spatial structure and potential declines in environmental quality and food security The results of the model validation showed an overall accuracy of 93.57% and a Kappa Accuracy of 90.02%, which explains that the data used meets the requirements of a model with a high level of accuracy intended for geographic information system analysis. [1], [33].

CONCLUSION

The dynamics of land use changes in Kediri Regency over the period 2008–2023 reflect a significant transformation of the area from an agrarian character towards an increasingly urban region. Spatial analysis indicates a rapid increase in built-up land, which has become the dominant phenomenon, along with population growth, urbanization, and regional economic development. On the other hand, there has been a significant decline in forest land, plantations, and especially rice paddies, indicating pressure on productive land resources and the environment. Interview results reinforce this finding that the primary drivers of change are human activities, including settlement expansion and community economic needs. The transition matrix also shows that the largest conversion occurs from agricultural land, particularly rice paddies, to built-up land, which has the potential to threaten future food security. Socio-economically, this change indicates a shift in the structure of community livelihoods from the agricultural to the non-agrarian sector, while ecologically it has an impact on the decline in environmental quality and regional carrying capacity. Therefore, sustainable spatial management is needed through the integration of spatial and temporal data, controlling land conversion, and adaptive policies to maintain a balance between economic development, environmental sustainability, and long-term community welfare.

REFERENCES

[1] Munawir, A., June, T., Kusmana, C., & Setiawan, Y. (2019). Dynamics factors that affect the land use change in the Lore Lindu National Park. Proceeding of SPIE 11372, Event : Sixth Internasional Symposium on LAPAN-IPB Satelite. Bogor Indonesia.

[2] Rusdiyanto, E., & Munawir, A. (2023). New built land threat of martapura river–implementation of environmental sustainability in Banjarmasin City, South Kalimantan, Indonesia. Journal of Ecological Engineering, 24(5).

[3] Esfandeh, S., Danehkar, A., Salmanmahiny, A., Sadeghi, S. M. M., & Marcu, M. V. (2021). Climate change risk of urban growth and land use/land cover conversion: An in-depth review of the recent research in Iran. Sustainability, 14(1), 338.

[4] Hansen, H. K., & Eriksson, R. H. (2023). The public sector and regional development: Why public sector employment remains a black box in economic geography, and how should we open it?. Progress in Human Geography, 47(6), 833-849.

[5] Fundeanu, D. D., & Badele, C. S. (2014). The impact of regional innovative clusters on competitiveness. Procedia-Social and Behavioral Sciences, 124, 405-414.

[6] Munawir A. 2017. Kajian Dampak Lingkungan Kegiatan Penambangan Tanah Timbun di Kota Kendari. Hasanuddin Student Journal. Vol. 1 No. (2): 109-119, Desember 2017P-ISSN:2579-7859, E-ISSN: 2579-7867. Universitas Hasanuddin. https://journal.unhas.ac.id/index.php/jt/article/view/2834/pdf.

[7] Coutts, A. M., Harris, R. J., Phan, T., Livesley, S. J., Williams, N. S., & Tapper, N. J. (2016). Thermal infrared remote sensing of urban heat: Hotspots, vegetation, and an assessment of techniques for use in urban planning. Remote sensing of environment, 186, 637-651

[8] Fadilah, I. N., & Munawir, A. (2024). Sustainable Regional Development Strategy for Dealing with the Distribution of Landfill Points in West Lombok Regency. ASTONJADRO, 13(3), 747-757.

[9] Das, S., Choudhury, M. R., Chatterjee, B., Das, P., Bagri, S., Paul, D., Bera, M., & Dutta, S. (2024). Unraveling the urban climate crisis: Exploring the nexus of urbanization, climate change, and their impacts on the environment and human well-being–A global perspective. AIMS Public Health, 11(3), 963.

[10] De Jong, L., De Bruin, S., Knoop, J., & van Vliet, J. (2021). Understanding land-use change conflict: A systematic review of case studies. Journal of Land Use Science, 16(3), 223-239.

[11] Esfandeh, S., Danehkar, A., Salmanmahiny, A., Sadeghi, S. M. M., & Marcu, M. V. (2021). Climate change risk of urban growth and land use/land cover conversion: An in-depth review

of the recent research in Iran. Sustainability, 14(1), 338.

[12] Munawir, A., Nurhasanah, Rusdiyanto, E., & Muna, S. U. N. (2022a). Sustainable mangrove forest utilization policy using interpretative structural modeling techniques in Rawa Aopa National Park, Southeast Sulawesi. Scientific Bulletin of Marina Socio-Economics of Marine and Fisheries. [in Indonesian].

[13] El Fitri, L. S. (2018). Pemekaran Kecamatan Dalam Peningkatan Pelayanan Kependudukan (Studi Pada Kecamatan Gampengrejo Kabupaten Kediri) (Doctoral dissertation, Brawijaya University).

[14] Fang, C., & Yu, D. (2017). Urban agglomeration: An evolving concept of an emerging phenomenon. Landscape and urban planning, 162, 126-136.

[15] Warsono, A. (2006). Perkembangan Permukiman Pinggiran Kota Pada Koridor Jalan Kaliurang Kecamatan Ngaglik Kabupaten Sleman (Doctoral dissertation, program Pascasarjana Universitas Diponegoro).

[16] Fiantika, F. R., Sa'Dijah, C., Qohar, A., & Darsono. (2020, February). Link between modern building and Kediri's tradition: An idea to develop teaching-learning equipment. In Journal of Physics: Conference Series (Vol. 1470, No. 1, p. 012001). IOP Publishing.

[17] Maylin, M. I. (2019). Konstruksi Sosial Simpang Lima Gumul (Studi Makna Simpang Lima Gumul bagi Masyarakat Desa Tugurejo dan Desa Sumberejo, Kecamatan Ngasem, Kabupaten Kediri) (Doctoral dissertation, Universitas Airlangga).

[18] Istiqomah, N. Z., Setyono, D. A., & Hasyim, A. W. (2025). KARAKTERISTIK HARGA LAHAN DI KAWASAN SEKITAR BANDARA DAN JALAN TOL KABUPATEN KEDIRI. Planning for Urban Region and Environment Journal (PURE), 14(4), 107-116.

[19] Hoornweg, D., & Pope, K. (2017). Population predictions for the world's largest cities in the 21st century. Environment and urbanization, 29(1), 195-216.

[20] Munawir, A., Rusdiyanto, E., Naili Muna, S. U., Ali, F., & Ihsan, M. (2024). Improving Waste Management Sustainability: The Role of Institutional Capacity and Program Objectives. Journal of Natural Resources and Environment Management, 14(3).

[21] Central Statistics Agency (BPS). Kediri Regency in 2022.

[22] Munawir, A., June, T., Kusmana, C., & Setiawan, Y. (2022). SEBAL Model to Estimate Biophysics and Energy Flux Variable: Availability of Evapotranspiration Distribution Using Remote Sensing in Lore Lindu National Park. In IOP Conference Series: Earth and Environmental Science (Vol. 950, No. 1, p. 012022). IOP Publishing.

[23] Mohan, M., & Kandya, A. (2015). Impact of urbanization and land-use/land-cover change on diurnal temperature range: A case study of tropical urban airshed of India using remote sensing data. Science of the Total Environment, 506, 453-465.

[24] Lukman, L., Sodikin, S., & Munawir, A. (2024). Mangrove Management Strategy as a Conservation Effort in Coastal Tarakan City. ASTONJADRO, 13(3), 791-804.

[25] Muna, S. U. N., & Munawir, A. (2024). Net single premium determination of crop insurance product based on rainfall and temperature. In AIP Conference Proceedings (Vol. 3048, No. 1). AIP Publishing.

[26] Masnur, B., Rusdiyanto, E., & Munawir, A. (2023). Analysis of Environmental Management Policy Strategies Due to Increased Land Built in Pekanbaru City. Jurnal Indonesia Sosial Teknologi, 5(7), 3174.

[27] Putri, N. A. (2020). Dinamika perencanaan tata guna lahan di Kabupaten Kediri. Jurnal Ilmiah Administrasi Publik, 6(3), 431-438.

[28] T Hidayat, A. R. (2018). Peri-urban farmland owner in the growing municipality, case study Kediri Municipality. In IOP Conference Series: Earth and Environmental Science (Vol. 202,

No. 1, p. 012025). IOP Publishing.

[29] Seto, K. C., Güneralp, B., & Hutyra, L. R. (2012). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proceedings of the National Academy of Sciences, 109(40), 16083-16088.

[30] Chen, S., Woodcock, C. E., Gu, H., Dong, L., Tang, X., & Olofsson, P. (2026). Drivers of forest disturbance in Southeast Asia. International Journal of Applied Earth Observation and Geoinformation, 148, 105220.

[31] Aljaddani, A. H., Song, X. P., & Zhu, Z. (2022). Characterizing the patterns and trends of urban growth in Saudi Arabia's 13 capital cities using a Landsat time series. Remote Sensing, 14(10), 2382.

[32] Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M., & Rieseberg, L. H. (2018). Trends in global agricultural land use: implications for environmental health and food security. Annual review of plant biology, 69, 789-815.

[33] Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. Annual review of environment and resources, 28(1), 205-241.