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New Built Land Threat of Martapura River – Implementation of Environmental Sustainability in Banjarmasin City, South Kalimantan, Indonesia

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ABSTRACT
The threat of environmental degradation of the Martapura River as a result of an increase in built-up land has become a serious problem, so it is important to implement a new method using the integration of calculations of changes in built-up land and the sustainability of river area environmental management. This study aimed to calculate the change in built-up land directly integrated through Rap-RiverBuiltUp quantitative analysis on the environmental sustainability of the Martapura river area, Banjarmasin City. The research method used is the technique of spatial analysis of ETM/Landsat 8 OLI satellite landsat images and analysis of ecological, social and economic sustainability with Rap-RiverBuiltUP analysis. The results of the analysis of built-up land around the Martapura river, Banjarmasin City, have increased by 2.31% over the last 12 years, followed by a growth in population density of ±1.5% annually. The implementation of sustainable environmental management needs to be prioritized with the efforts to periodically revise regional spatial planning regulations, especially the boundaries of built-up land to reduce the development of built-up land around the Martapura River. The sustainability status of the built-up area around the Martapura river is currently not sustainable. The ecological dimension indicates a less sustainable status, while the economic and social dimensions indicate a fairly sustainable status. Increasing the sustainability index value of the Martapura river from each dimension in the future is by making the lever factor an input for the management policy of the Martapura river, Banjarmasin City.

Keywords: threat of environmental degradation, land use, sustainability of martapura river, built-up land.

INTRODUCTION

Land change has become a serious problem throughout the world (Rozario et al., 2017; Yang et al., 2014; Mondal et al., 2016), impact on a serious threat to environmental sustainability (Fearnside, 2016; Kamusako et al., 2009). Rapid land use change has occurred in many parts of Indonesia (Rafiudin et al., 2016; Edwin et al., 2015). This condition results in a negative impact on the status of environmental sustainability, where the serious threat of environmental degradation is certain to occur in the next few years (Adrianto et al., 2021). The increase in land change is caused by human activities so that it is a serious concern today, because it has an impact on environmental damage and human health (Jat et al., 2008; Mallupatu and Reddy, 2013). The research on land use/cover change (LU/LC) is very important to be carried out in order to be able to conduct planning and utilization of natural resources by considering environmental sustainability (Munawir et al., 2019; Lambin et al., 2014). The city of Banjarmasin is a riverside city which shows the development of the city with trade, service and industrial activities. The different conditions are changes in land use in the river network which are increasing very rapidly. The impact on the spatial structure of settlements changes according to the conditions that occur, giving rise to a spatial variety in the area (Ernoul and Wardell-Johnson., 2013; Sevtsuk et al., 2013). On the other hand, it also has another impact that is no less important, namely the rapid and uncontrolled growth of settlements, resulting in disorder and a decline in the quality of the riverside settlement environment (Luo et al., 2014; Rusdiyanto et al., 2020a). Settlements have a broader meaning than housing, so that settlements should provide comfort to their inhabitants, including the people who come to these places (Hidajat, 2014; Rusdiyanto et al 2020b). Along with the increase in population and the need for space for shelter, humans tend to change a place including river banks and the environment around the river to become their place of residence which should be free from development (Chair et al, 2021; Anaba et al, 2017). The free development around the river and the absence of restrictions on these things make several rivers, especially the Martapura river in Banjarmasin City, slowly lose their function (Michiani dan Asano, 2019; Nisa, 2011). In fact, it is not uncommon for rivers to become landfills for the community (Dahliani, 2018; Adrianto, 2021; Chair et al., 2021; Roy dan Lees, 2020). Hereditary habits such as the cultural power of the community regarding the use of rivers as MCK have an impact on river pollution (Wulandari et al., 2019; Nakamura, 2014). An increase in residential land use that exceeds the capacity of the land has the potential to cause a decrease in land use (Maestro et al. 2019; Munawir et al. 2022). If this situation continues to be allowed, it will trigger environmental degradation (Balteanu and Anna, 2010; Abera et al., 2022). The impacts that occur due to environmental degradation, not only result in land deterioration in quality and productivity, but also endanger the socioeconomics of the community (Salmah, 2012; Rustiadi et al., 2001). As a result of these impacts, environmental degradation is currently an important concern from various parties (Anshari et al., 2010; Gurney et al., 2016; Kubangun et al., 2016; McAlpine et al., 2009; Munawir et al., 2022a).

The waters area of the Martapura river, Banjarmasin City, has experienced a rapid increase in development, which becomes a problem when this development does not pay attention to aspects of environmental sustainability, and will have an impact on environmental conditions such as pollution and land change, both directly and indirectly. These land changes are related to the changes in the function and distribution of productive areas such as in industrial areas, settlements and transportation systems, including changes in the quality and quantity of infrastructure systems or regional infrastructure (Neinmark et al., 2018; Sheikh et al., 2013). This change is also inseparable from the implementation of policies and the reciprocity of land use around the river (Lambin and Meyfroidt, 2010; Gu et al., 2016). The research related to environmental threats and degradation has been carried out throughout the world and Indonesia is mainly related to the degradation of the Colorado and San Juan rivers (Curley, 2019), land use change along the Ethiopian Tekeze-Atbara basin (Gebremicaelabc et al., 2018), land degradation due to land change in the Heihe watershed of China (Shao et al., 2020), land use change in the Brisbane River Australia (Kemp et al., 2014), land change factor in the estuary of the Tallo River, Makassar (Yusuf et al., 2016), and river water resource management efforts (Sari et al., 2012; Paimin et al., 2012). This research is very different from most studies carried out around the world and Indonesia, because overall in the research conducted there was a little development on the analytical methods used, whereas the focus of research in several countries in the world and Indonesia is only on the impact of land change and degradation studies but not much research related to the integration of calculations of changes in built-up land and the sustainability of river area environmental management is conducted. For this reason, this study aimed to calculate the changes in built-up land directly integrated through quantitative analysis of the environmental sustainability of the Martapura river area, Banjarmasin City. Research contributions can provide information as a basis for sustainable development planning from the results of calculations of changes in built-up land in the Martapura river area and ensure increased social, ecological and economic environmental sustainability.

RESEARCH METHOD

Date and study site

This research was conducted in the vicinity of the Martapura river, administratively located in the City of Banjarmasin, South Kalimantan Province. Geographically and astronomically, it is located between 3°16’46” – 3°22’54” S and 114°31’40” – 114°39’55” E. The area of Banjarmasin City is 98.46 km^2 or about 0.26% of the total area of South Kalimantan Province which consists of 5 sub-districts and 52 sub-districts (BPS Kota Banjarmasin 2014). The city of Banjarmasin is also known as the City of a Thousand Rivers. This is because the city of Banjarmasin is crossed by many rivers, ranging from large rivers to small rivers. The major rivers in Banjarmasin City are the Barito River and the Martapura River. The city of Banjarmasin itself is divided by the Martapura River which gives its own characteristics to people's lives, especially the use of the river as a means of water transportation, trade and even tourism. Community life in the city of Banjarmasin cannot be separated from the existence of these rivers. The map of the research location for the Martapura river, Banjarmasin City, can be presented in Figure 1.

MATERIAL AND METHODS

The tools used in this research were Global Positioning System (GPS), camera, tripod, fish eye lens, compass, measuring tape, sewing meter, hypsometer, guidebook, tally sheet, stationery, ArcGIS 10.9 software, Erdas Imagine 2014 software, Google Earth Engine, Hemiview Canopy Analysis Software, SexI-FS software, Corel Draw, and Microsoft Excel. The materials needed are Landsat 7 ETM and Landsat-8 OLI Path/Row 118/62 satellite images. The digital map of the administrative boundaries of Banjarmasin is used as primary data, while the secondary data is in the form of a Regional Spatial Planning (RSP) Compilation Report from BAPPEDA for 2020, Banjarmasin City Statistical Data in Figures for 2022 from the Central Bureau of Statistics (BPS) for Banjarmasin City. Landsat 7 TM in 2010, Landsat 8 OLI in 2014, 2018 and 2022.

RESEARCH PROCEDURE AND SPATIAL ANALISIS

Retrieval of data in the field refers to image preprocessing to identify the groups of built-up land in the field as initial data to then check the suitability of the intensity of other land conversions at the research location. The results of image preprocessing are in the form of pictures of the research location area which will be used as a reference for data collection before field checking is carried out and then grouped into several land use classes. The image preprocessing stage is geometric correction and radiometric correction. In the geometric correction stage, the first step taken is layerstacking which performs the image fusion process from several channel dimensions into one and vice versa. The process through layerstacking is carried out on multispectral images which are still separated between channels. The downloaded images come from Landsat 7 and Landsat 8, which consist of several bands subjected through a layer stacking process using ERDAS 2014 and GIS 10.9. After layerstacking, the coordinates of

Figure 1. Map of Martapura River Research Location in Banjarmasin City, South Kalimantan Province, Indonesia

the image are adjusted to match the geographic coordinates. Geometric corrections are performed to obtain the actual pixel values at the right position (Ratri 2018). The last is a subset, where the image cutting process is carried out based on the Area of Interest (AOI). The data needed is the results of mosaic and shapefile of research locations that have been carried out in the previous cutting stage so that land change intensity classification can be carried out.

Passage of sunlight and an object to the camcorder through atmospheric media (Sukojo and Kustarto 2002). The geometric correction is carried out with the intention that the spectral response on land has a uniform value to avoid misclassification of the input data. Landsat 7 and Landsat 8 data were radiometrically corrected using reflectance Top of Atmospheric (TOA) correction. The reflectance TOA correction is used to change the digital number value to a reflectance value. The equation is as follows:

$$\rho\lambda' = M\rho \cdot Qcal + A\rho \quad (1)$$

$$\rho\lambda = \rho\lambda \cdot \sin \Theta \quad (2)$$

where: $\rho\lambda'$ – TOA reflektan, $M\rho$ – reflectance value MUL_BAND_X, $Qcal$ – digital number value (DN), $\rho\lambda$ – TOA planetary reflectance (unitless), Θ – solar elevation angle (rad).

Field data in the form of land maps are used to produce an error matrix to measure the accuracy of the thematic maps produced (Weismiller et al 1977; Jaya, 2015). The matrix estimates field observation data and performs a producer accuracy test (the probability that each land cover class pixel has been correctly classified). In addition, an overall accuracy test (proportion of pixels correctly graded) as well as Kappa statistics (Congalton and Green, 2009) were performed. Accuracy tests are not carried out based on objects or accuracy tests related to the geometric accuracy of objects such as location and shape (Whiteside et al., 2011). The classification system for making land use systems uses Supervised Classification which is assisted by inspections using the Global Position System (GPS). Calculation of the dynamics of land use change is used to determine the level of change in the increase in built-up land (Wang and Bao, 1999; Zhang, 2010).

Factor analisys sustainability

Assessing the sustainability of built-up land in the Martapura river area of Banjarmasin City using multidimensional scaling (MDS) called Rap-RiverBuiltUp. This method was developed by modifying the Rap-Fish method (The Rapid Appraisal of the Status of Fisheries) which has been used so far to assess the sustainability status of fisheries (Munawir et al, 2022b); Rusdiyanto et al, 2020). Rap-RiverBuiltUp analysis will produce the status and sustainability index of built-up land around the Martapura river. The index value for the sustainability of built-up land around the river is called Rap-RiverBuiltUp. Monte Carlo analysis helps to see the effect of errors in scoring each attribute. The chart of the research data collection methods for the Martapura river can be presented as follows:

Based on Figure 2, the analysis procedure of this research uses the integration of multi-temporal image spatial analysis approaches Landsat 7 ETM+ 2010 and Landsat 8 OLI 2014, 2018, 2022 to determine the impact of land conversion sustainability and then analyzes the sustainability of the Martapura river settlement by examining the actual approach to settlements around the Martapura river the city of Banjarmasin by knowing the MDS Ordination, Montecarlo Analysis, Leverage of attribute and status of sustainability due to an increase in population on the other hand the condition of the sustainability of settlements is increasingly threatened due to lack of attention and environmental management which has an impact on increasing the slums around the Martapura river, Banjarmasin City.

RESULTS AND ANALYSIS

Threats of change in the martapura river built-up land

Analysis of land change as presented in Figure 3 shows that the increase in built-up land around the Martapura river, Banjarmasin City has increased over the last 12 years, in 2010 the area of built-up land was around 4665 ha and in 2014 it became 4805 ha. The increase in the area of built-up land is directly related to the growth of population density based on the information from the Central Bureau of Statistics (BPS, 2010) for the city of Banjarmasin in 2010, around 6380 people/km^2, there was a significant

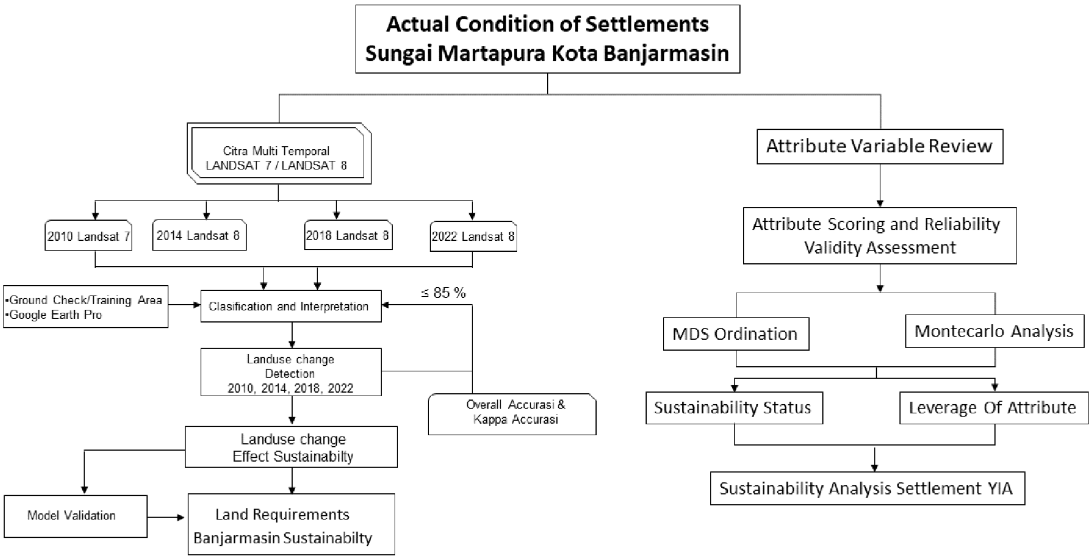


Figure 2. Research procedures

increase in 2014 to 6766 people/km^2 (BPS, 2014). Different results are aimed at an increase in new built-up land in 2018 of 4940 ha and an increase in 2022 of 5255 ha (Figure 3), there was an increase in the area of uncontrolled built-up land, especially on the banks of the Martapura river as a result of the culture of the people who tend to build settlements around the river because they think that the condition of the river is related to religious concepts and forms of residential patterns (Wulandari et al., 2019). On the basis of the spatial interpretation analysis, it has provided complete information in the field due to the fact that it describes the actual conditions

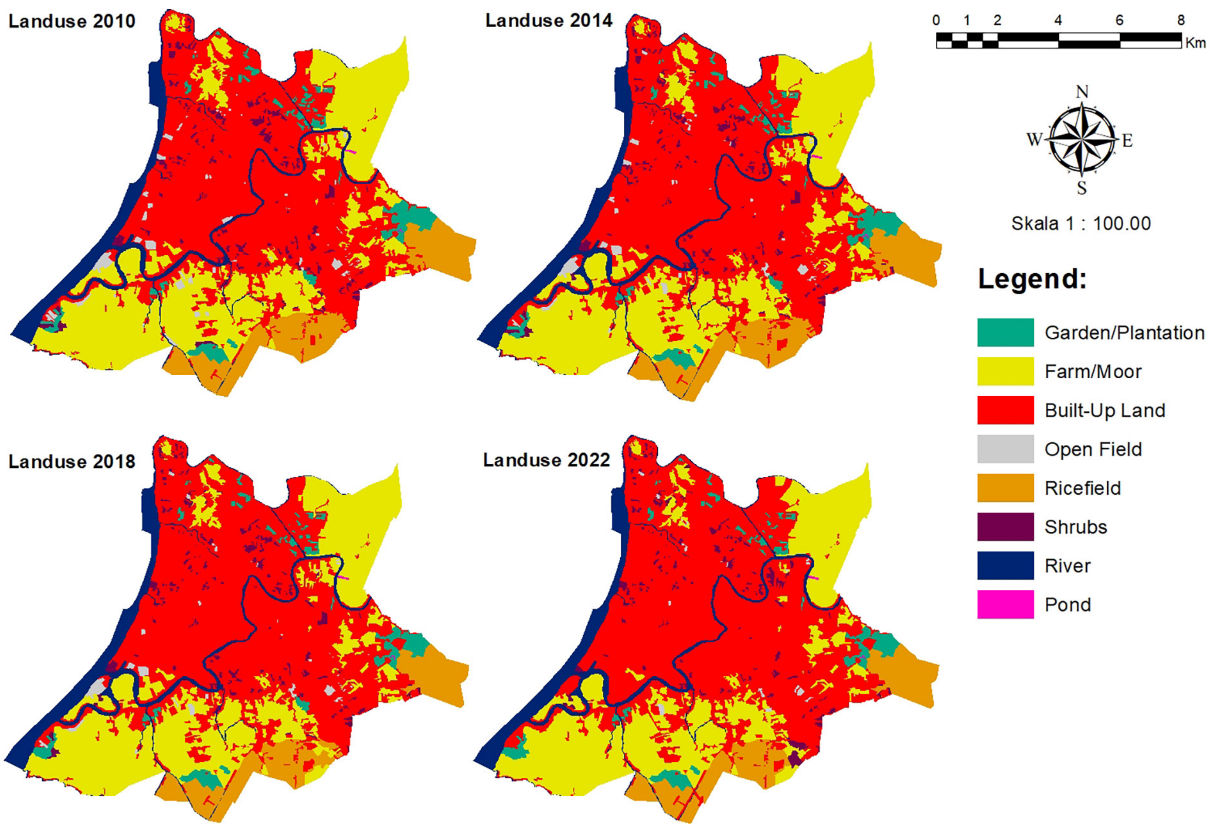


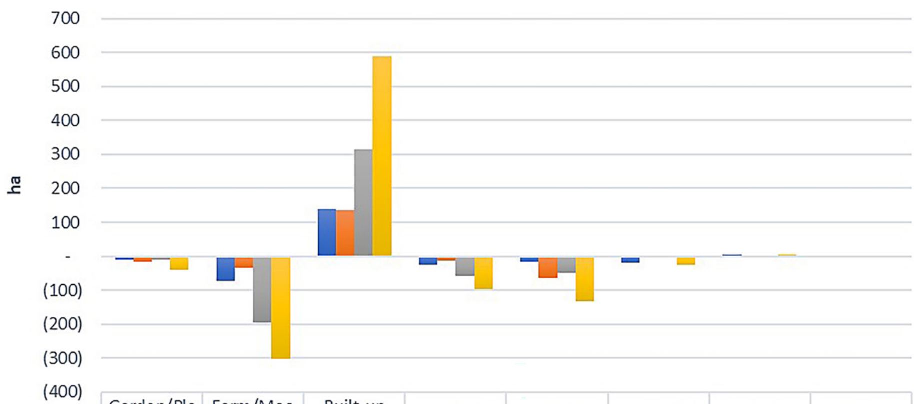
Figure 3. Change of built-up land (2010, 2014, 2018, 2022)

in the field, because there are still many pressures found around the Martapura river at certain levels such as adding built-up land, building construction, expanding fields/moor fields and other land changes for needs. community as a result of high population growth in the city of Banjarmasin.

The results of the 2012 Landsat 7 ETM satellite imagery recording compare the difference in the 5 year period for recording using the 2014 Landsat 8 OLI, the 2018 Landsat 8 OLI and the 2022 Landsat 8 OLI recording, the results of the analysis indicate that the Martapura river basin has experienced pressure, it can be seen that several areas have changed to other lands (Figure 5), and this pressure continues to increase in 2014, 2018 and 2022. The overall results explain that the increase in built-up area is experiencing pressure changes due to population density factors followed by high urbanization rates and the culture of local people living around streams river. According to Setiawan (2010), the development of population density mainly due to increased urbanization has resulted in vulnerability to changes, especially the increase in the settlements that do not pay attention to the environment. It is estimated that this pressure will have an immediate impact, the impact that can be felt and seen immediately is the changing environmental conditions that are friendly, clean and green into slums and experiencing disorder (Michiani and Asano, 2019). An increase in built-up land in the areas that are not suitable for its designation can endanger the surrounding environment and even lives of residents of the areas around watersheds (Curley, 2019; Kemp et al., 2014).

In Figure 4, it can be seen that the distribution of built-up area in the Martapura river, Banjarmasin City from 2010–2014 tends to increase; this condition causes an increase in built-up area of 140 ha. A very significant increase changed around the Martapura river in the 2010–2022 period of 301 ha. On the basis of the trend of increasing built-up land which continues to occur every year, it requires serious attention from all stakeholders (Munawir et al., 2022a), in order to maintain the condition of the carrying capacity of the environment and the sustainability of the Martapura river basin. Many studies have provided warnings to maintain watershed sustainability (Shao et al., 2020; Kadir, 2016; Fauzi, 2014). Government policy, especially the government of Banjarmasin City, is to immediately play its role as a facilitator and catalyst for development that is proactive and productive in managing built-up land and watersheds as well as supports and provides space for the community to participate in community-based management (Luo et al., 2014; Roig-Munar et al., 2012).

On the basis of the results of the analysis in Table 1, it shows that the changes in land use around the Martapura river, Banjarmasin City from 2010 to 2022, the area of fields/moors tends to experience land change of 1.25% followed by an increase in built-up land of 2.31%. This result is in line with the opinion of Liang et al. (2011) that the dynamics of land use change characterizes the degree of ease with which conversion occurs from a type of land use from time to time. The dynamics of land conversion can help



	Garden/Plantation	Farm/Moor	Built-up Land	Open field	Ricefield	Shrubs	River	Pond
Period 2010-2014	(11)	(72)	140	(25)	(17)	(21)	5	-
Period 2014-2018	(16)	(35)	135	(13)	(65)	(5)	-	-
Period 2018-2022	(12)	(194)	315	(58)	(51)	(0)	-	-
Period 2010-2022	(39)	(301)	590	(96)	(132)	(26)	5	-

Figure 4. Built-up land change matrix (2010, 2014, 2018, 2022)

Table 1. Estimated area of land change in the research location (ha)

Land use	2010		2014		2018		2022	
	Ha	%	Ha	%	Ha	%	Ha	%
Garden/plantation	301	3.05	290	2.95	274	2.78	262	2.66
Farm/moor	2911	29.56	2839	28.83	2804	28.48	2610	26.51
Built-up land	4665	47.38	4805	48.80	4940	50.17	5255	53.37
Open field	127	1.29	102	1.04	89	0.90	31	0.31
Ricefield	864	8.77	847	8.60	782	7.94	732	7.43
Shrubs	246	2.50	226	2.29	220	2.24	220	2.23
River	729	7.40	734	7.45	734	7.45	734	7.45
Pond	4	0.04	4	0.04	4	0.04	4	0.04
Total	9847	100.00	9847	100.00	9847	100.00	9847	100.00

monitor the differences in the benefits generated by the amount of input/output of a land area for a certain duration of time (Gu et al. 2016); on the other hand, Veldkamp and Lambin (2011) argue that the complexity of interactions between natural and socio-economic systems largely determined by the development of the region.

The results of the spatial analysis of the Martapura river area, Banjarmasin City, were validated using the overall accuracy and kappa accuracy validation models. The validation calculation is based on field measurements (ground check points) and the weight of the calculation of the number of pixels that are grouped correctly for all land use classes then divided by the total pixels used. The land area of the Martapura River during the study was around 92%, while the kappa accuracy obtained was 90.7%.

Sustainability analysis (rap-riverbuiltup)

Analysis of the sustainability of the built-up land around the Martapura river with various determinants of sustainability from social, economic and ecological analysis. On the basis of the Rap-RiverBuiltUp review, it can be concluded that there has been pressure from the results of the MDS analysis test which was used with a high level of accuracy (goodness of fit) according to the results of the sustainability assessment of built land around the Martapura river, Banjarmasin City. The sustainability index of built-up land around

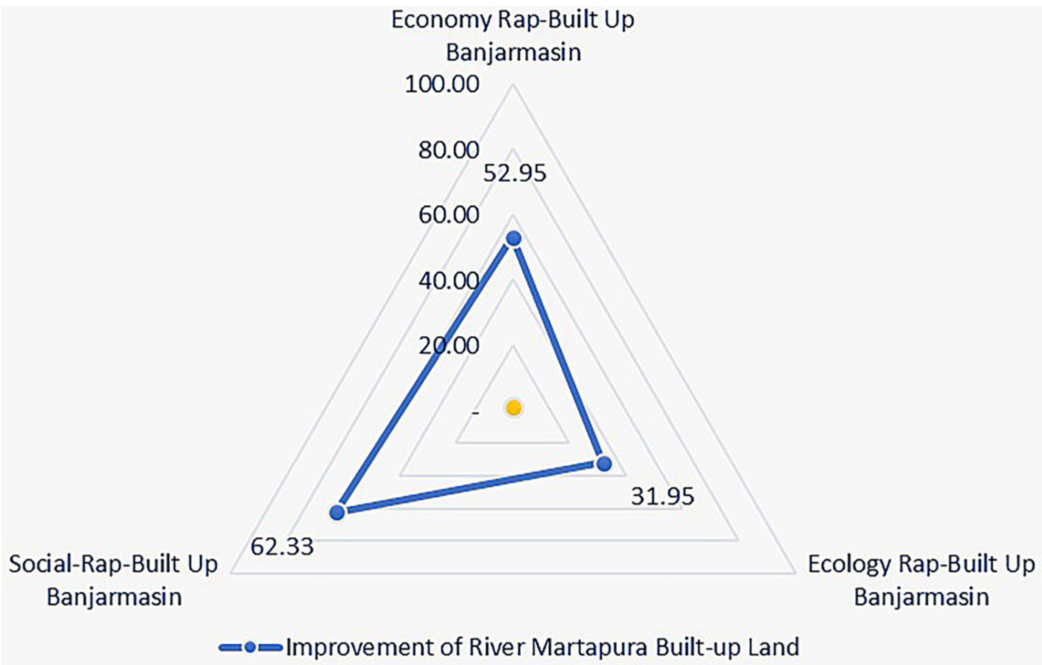


Figure 5. Kite-diagram sustainable index rap-riverbuiltup

the Martapura river, Banjarmasin City is shown in the kite diagram as shown in Figure 5 below. Urban areas are very vulnerable to change, bearing in mind that in the future urban areas will experience changes from simple settlements to settlements with a modern perspective (Rustiadi et al., 2019; Badmos et al., 2019). Simple settlements are synonymous with neighborhoods with high population density and are dominated by lower middle-income residents (Michiani and Asano, 2019). Overcoming irregular settlements needs to be studied in several developed countries in the world with international experience, so that development success is achieved with ecological considerations. The Rap-RiverBuiltUp analysis reveals that the three dimensions have a Rap-RiverBuiltUp value of 49.08. This value reflects that the sustainability of settlements is classified as unsustainable multidimensionally, with an average stress value of 13% and R = 95%. This value is obtained based on the assessment of 28 attributes which fall into three dimensions, namely the ecological dimension (8 attributes), the economic dimension (10 attributes), and the social dimension (10 attributes). Sustainability index values for each ecological, social and economic dimension were obtained, the values of the difference and R2 are presented in Table 2.

On the basis of the results of the sustainability analysis, it was shown that the built-up land around the Martapura river is currently experiencing high pressure from 3 (three) dimensions of sustainable development. The trade-off dimensions of built land arrangement can be seen in the kite-diagram as shown in Figure 6. The kite-diagram shows the trade-off of the three dimensions of sustainable built land, there is a very prominent dimension of built land management where the less sustainable value ranges from 31–62%. This means that each assessment dimension can provide an effect that is almost the same on the increase in built-up land (Pitcher, 2009; Kavanagh and Pitcher, 2004).

The magnitude of the influence of each dimension of sustainability is also evident from the results of the attribute leverage analysis (Figure 6), where the root mean square (RMS) value

Table 2. Results of MDS, Montecarlo, and statistical analysis

Dimension of sustainability	Sustainability index			Statistics	
	MDS	Montecarlo	Difference	Stress	R2
Ecology	31.95	30.47	1.48	0.12	0.96
Economy	52.95	52.54	0.41	0.14	0.94
Social	62.33	62.22	0.11	0.13	0.94
Multidimension	49.08	48.41	0.67		

a)

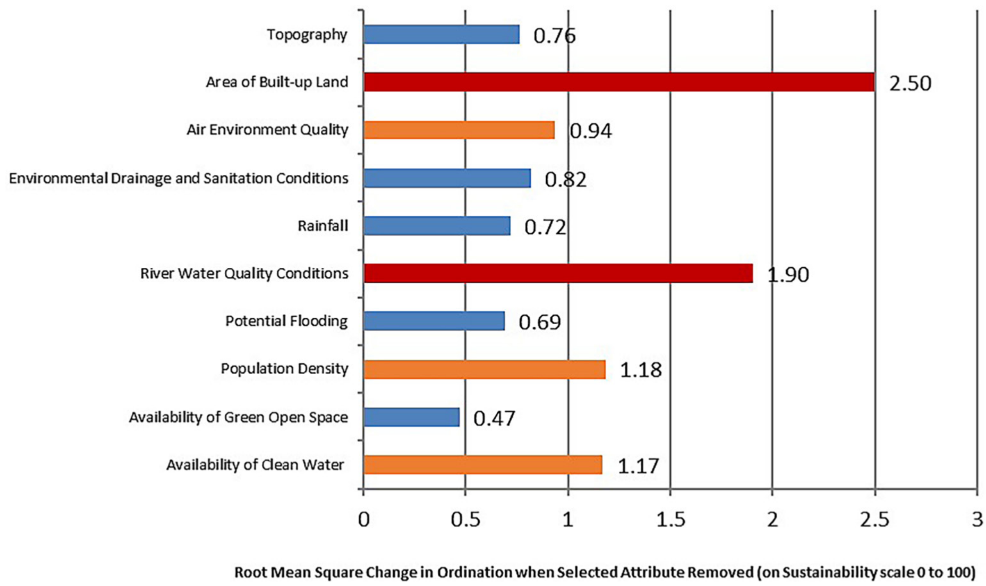


Figure 6. Leverage of ecological (6a), economic (6b) and, social (6c) attributes on sustainability score

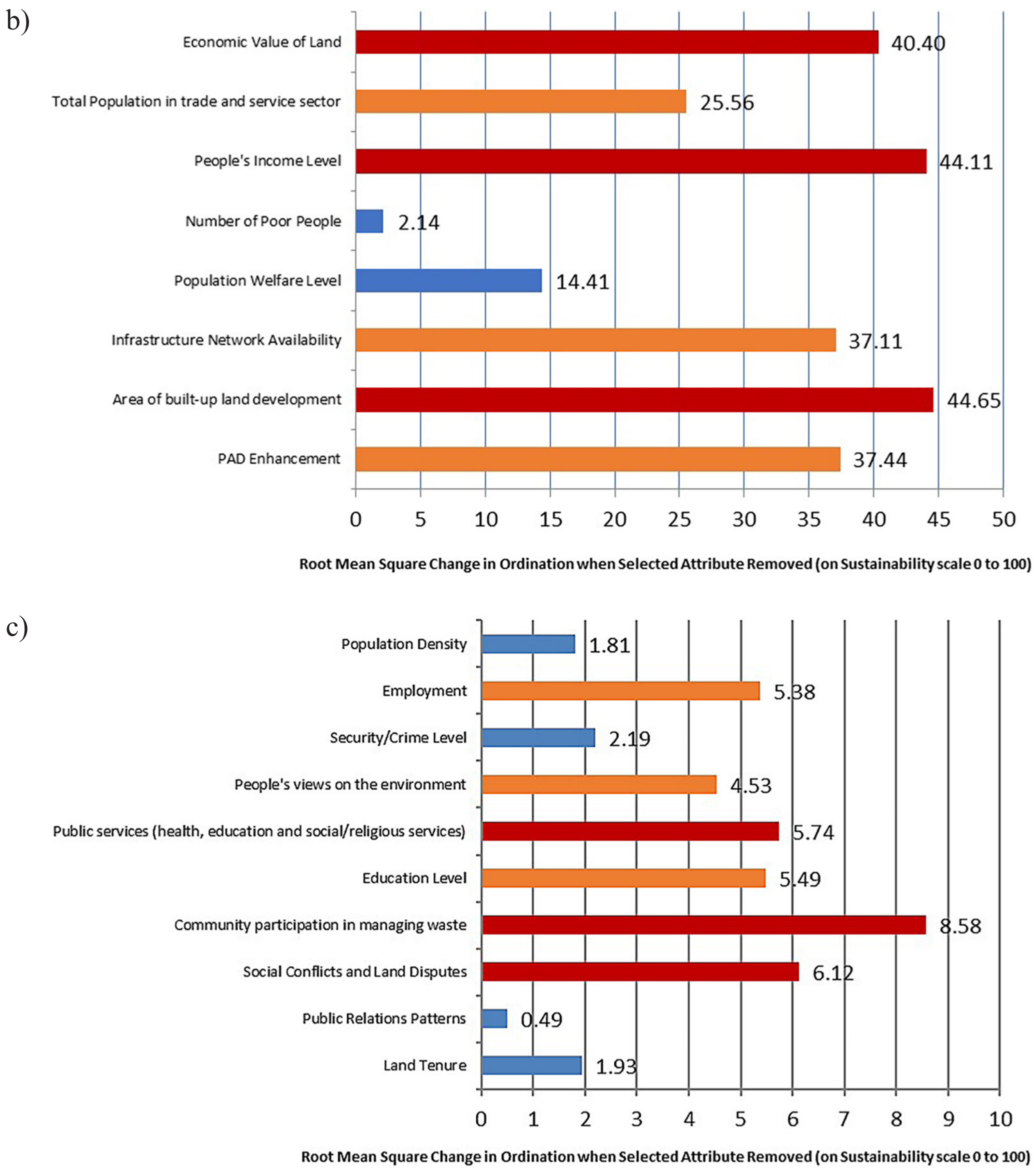


Figure 6. Cont. Leverage of ecological (6a), economic (6b) and, social (6c) attributes on sustainability score

indicates the large role that this attribute plays in the sensitivity of sustainability status (Kavanagh and Pitcher, 2004). The error rate in using the MDS technique on RiverBuiltUp is relatively small (Table 2). This is shown by the relatively small difference between the Rap-RiverBuiltUp analysis using MDS and the Monte Carlo technique at the 95% confidence level. The ecological dimension lever analysis of the 10 ecological dimension attributes resulted in 2 attributes with significant and prominent RMS change values, namely: the area of built-up land and the condition of river water quality (Figure 6a). Sustainability analysis on the economic dimension is better, because the conditions that have good and moderate scores can be improved and this is highly likely to improve, because judging from the current conditions in the research area, the economic activities are quite good and developing, especially related to the tourism development activities around the land the city of Banjarmasin which were awakened. The results of the leverage analysis of the 8 attributes of the economic dimension yielded 3 attributes with prominent RMS change values, namely the area of built-up land development, the level of community income and the economic value of the land (Figure 6b). The social dimension lever analysis of the 10 attributes produces 3 sensitive attributes, namely community participation in waste management, social conflicts and land disputes; the final is public services (health, education and social/religious services (Figure

6c). Currently, these three attributes are a sensitive attribute for the successful management of built-up land areas in the study area, if the intensity increases, then the sustainability status of the ecological dimension in the Martapura river basin will tend to decrease. Therefore, the growth rate of built-up land and increased population growth must be controlled as soon as possiblein addition to as drainage conditions and environmental sanitation, especially the efforts to manage waste in the watershed must be followed up so that it does not pollute the river water environment (Luo et al., 2014; Chen et al. 2014; Li and Gu, 2012).

CONCLUSION

Calculation of the changes in built-up land around the Martapura river, Banjarmasin City, has increased by 2.31% over the last 12 years followed by a growth in population density of ±1.5% annually. The implementation of sustainable environmental management needs to be prioritized with the efforts to periodically revise regional spatial planning regulations, especially the boundaries of built-up land to reduce the development of built-up land around the Martapura River. The sustainability status of the built-up area around the Martapura river is currently not sustainable. The ecological dimension indicates a less sustainable status, while the economic and social dimensions indicate a fairly sustainable status. The part that has the lowest sustainability index and has the attribute that has the highest sensitivity on the ecological dimension is the area of built-up land and the condition of river water quality; Attributes that have the highest sensitivity to the economic dimension are the area of built-up land development, the level of community income and the economic value of the land; and Attributes that have the highest sensitivity on the social dimension are community participation in waste management, social conflicts and land disputes, and public services (health, education and social/religious services); 2) the resulting leverage factor is 28 attributes whose existence influences sensitively, and one of the leverage factors is the area of built-up land and community participation in managing waste. Increasing the value of the sustainability index of the Martapura river from each dimension in the future is by maintaining the area of built-up land and community participation efforts in managing waste as a leverage factor, as well as making the leverage factor an input to the Martapura river management policy, Banjarmasin City.

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