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Spatial-Temporal Variation of Land Use Changes In Ambon City

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Abstrak

Perubahan penggunaan lahan telah menimbulkan berbagai konsekuensi spasial yang terjadi secara substansial pada suatu kawasan. Studi ini mengkaji pola perubahan penggunaan lahan dari variasi ruangan yang berbeda. Penelitian dilakukan di sebuah lokasi di Kota Ambon. Materi dalam penelitian ini adalah Landsat 8 OLI/TIRS tahun 2010 dan 2020, DEM SRTM, peta administrasi, dan peta pusat pengembangan. Data penelitian dianalisis secara deskriptif analitis, spasial dan temporal dari hasil overlay. Hasil kajian menunjukkan perubahan selama sepuluh tahun (2010-2020), menunjukkan peningkatan luas lahan terbangun seluas 23.810 ha per tahun. Perbedaan variasi spasial berdasarkan tapak administratif, penambahan blok di Kecamatan Sirimau seluas 76.880 ha, dan penarikan lahan paling signifikan pada kebun campuran yang mengelilingi seluas 58.859 ha. Selain itu, penambahan persenjataan di lereng curam (15 -30%) seluas 38.503 ha dan kawasan lindung seluas 16.505 ha dengan mengkonversi penggunaan lahan hutan seluas 17.366 ha, dan sebagian besar terjadi di Pusat kota. Penambahan lahan terbangun juga terjadi pada area aksesibilitas (< 3 km) seluas 116.370 ha, sebagian besar tersebar di pusat sekunder seluas 86.520 ha.

Kata Kunci *:* penggunaan lahan, Landsat 8, analisis spasial, overlay

Abstract

Changes in land use have caused various spatial consequences that occur substantially in an area. This study examines the pattern of land use changes from different room variations. The research was at a location in Ambon City. The materials in this study are Landsat 8 OLI/TIRS in 2010 and 2020, DEM SRTM, administrative maps, and development center maps. Research data were analyzed descriptively analytical, spatial and temporal from the overlay results. The study results in show changes over ten years (2010-2020), indicating an increase in built-up area covering an area of 23,810 ha per year. Differences in spatial variations based on administrative site, additional blocks in Sirimau District covering an area of 76,880 ha, and withdrawal of the most significant land in mixed gardens surrounding an area of 58,859 ha. In addition, there was additional weaponry on steep slopes (15 -30%) covering an area of 38,503 ha and a protected area of 16,505 ha by converting the use of forest land covering an area of 17,366 ha, and most of it took place in the city center. The addition of built-up area also occurred in an accessibility (< 3 km) area of 116,370 ha, most scattered in secondary center of 86,520 ha.

Keywords : *land use, Landsat 8, spatial analysis, overlay*

INTRODUCTION

Globally, the frequency of human interaction and natural environmental conditions has significantly changed the earth's surface *(Song et al.*, 2018; Tesfaw *et al*., 2018). Using land resources to meet human space needs is essential in global change, along with increasing population growth (Wahyuni *et al*., 2014). Population developments and human activities continue growing to cause high land demand, especially for built-up land (Hapsary *et al.,* 2021). This space requirement has led to various intensive land use changes and has become a hot issue over the last few decades due to human activities (Ariti *et al*., 2015; Folberth *et al.,* 2020;).

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In addition, it is estimated that worldwide urbanization will reach more than 80% and become a significant problem due to an increase in population that causes changes in land use (Liao *et al.*, 2019; Salerno *et al.*, 2018). Various developments in urban areas have become factors driving urbanization related to the existence of residents as an attraction in boosting the economy (Febianti *et al.*, 2022; Harahap, 2013). As a result, this urbanization has had a sizeable spatial impact on the increasingly limited demand for land resources to meet the human economic structure (Edan *et al.,* 2021). Rapid urbanization has led to the physical spread of cities outward (Mujiandari, 2014; Yunus, 2008) and has gradually become one of the dominant urban spatial expansion patterns worldwide. With a time difference reason and the consequences (Wang *et al.*, 2020; Hidayah *et al.*, 2022).

The development of urban areas today is an urgent problem in its management related to spatial use (Kusrini *et al.*, 2011). Urban growth is a humanistic phenomenon inherent in the earth's surface, which arises along with economic development and population growth. Currently, the world's urban population is approximately 3.9 billion people, or 4 percent, and is expected to reach 6.3 billion by 2050, with nearly 90 percent of the future increase in urban population being in cities in developing countries (Mosammam *et al.*, 2017). In developing countries, the number of urban areas in 2050 will be much larger than in 2000, with an increasing expansion rate (Angel *et al.*., 2011). Based on *World meters data*, in 2019, the increase in the population in urban areas reached 150.9 million people (55.8%) of the total population of Indonesia, which is around 270 million people. It is projected that in 2025 it will be close to around 170.4 million (59.3%) of the total population, namely 287 million (Bukhari, 2021).

This increase in population will, in turn, impact high population density in urban areas (Ghasemkhani *et al.,* 2020). Urban expansion continues to increase, causing high land use in the construction of various urban facilities (Lamidi et al., 2017). According to Yunus (2008). Increasing the urban population has significant spatial consequences for the need for land for housing (Lasaiba, 2013). This condition causes competition for urban land use to continue to increase, with increasingly limited land availability. This condition causes the world to experience pressure to face the problem of population growth (Asche *et al.*, 2015; Foley *et al.*, 2011).

Mapping land use change with Geographic Information Systems or GIS and remote sensing techniques can predict changes over time *(Butt et al.,* 2015), can process data with large capacity, is faster and more precise, and is flexible (Kumar, 2022), effective in terms of cost and time constraints (Haack & Rafter, 2006), and reduces various risks in field survey activities (Setiawan & Rachman, 2020). Linkage with GIS, simultaneously, remote sensing with various resolutions that can be applied both spectrally, radiometrically, spatially, and temporally (Yulianto *et al.*, 2019) and can be applied in assessing changes in land use over a certain period (Hapsary *et al.,* 2021). In addition, it becomes the basis for stakeholders in making policies related to spatial planning (Sya'ban & Adiputra, 2020).

Ambon is one of the cities in Indonesia. It is the capital of Maluku Province, functions as a center of economy, trade, and culture, and serves as the center of government. With an area of Ambon City of around 359.45 km^2, a population density of 1,191 people per km^2, and an annual population growth rate of 4.78%. Population growth in Ambon City is relatively high due to population migration. It has implications for urban development, which continues to grow and accumulate in the downtown area due to the availability of various city facilities and utilities. In addition, with the morphology of the city being mostly hilly, competition for flat land tends to be high. In hilly areas, cutting and filling valleys and protected areas have become the target of residents' efforts to build settlements and other built-up land. It was also marked by the construction of the Red and White Bridge as a link between the Leitimur and Leihitu Jazirah, causing the city to develop rapidly and linearly, especially on the main route that connects along the coast. As a result of the city of Ambon's ongoing development, it is necessary to investigate this issue to determine the spatial-temporal variation of changes in land use.

METHODS

This study examines the pattern and distribution of land use changes from the overlapping results of all parameters based on spatial variations based on remote sensing, GIS, and field surveys. The study was carried out in Ambon City, which is situated between 3^0 and 4^0 South latitude and 128^0 and 129^0 East longitude and extends to the inner and outer Ambon bays and inland around the Ambon Bay Waters, which the Leihitu and Leitimur Jazirah. The area of Ambon City is around 359.45 km2 with a coastline of 98 km, with boundaries divided into four sub-districts and 46 sub-districts or villages. Landsat 8 OLI/TIRS 2010 and 2020 (Path 109, Row 63) zone 52 on the WGS 1984 datum obtained from USGS GloVis for the extraction of land use maps and DEM SRTM with a resolution of 30 meters obtained from the National DEM for extraction slope, an administrative map, and a development center map from Bappeda Office, as well as conducting field observations, are the materials used in this study. While the tools used are geological compasses, digital cameras, Garmin handheld GPS, field stationery, and software, including Microsoft Excel, Er Mapper 7.0, ArcGIS 9.3, and Global Mapper 15.0.

In general, Landsat 8 image processing is carried out in several stages: image pre-processing, radiometric calibration, image visual interpretation using band math, image classification, and accuracy testing. These steps are carried out for two images that are temporally different. Next, the images are stacked (layer stacking is done) to allow for multispectral analysis, and the images are then cropped according to the focus area in this study. Furthermore, radiometric calibration is carried out by changing the pixel value (digital number) to a reflectance value. Image visual interpretation is based on the recognition of object characteristics spatially that can be identified based on different interpretations of each object, such as color, shape, size, pattern, texture, shadow, location, and association of object appearances. This visual interpretation uses math NDVI bands to bring out the greenery of the vegetation. Because the vegetation area is considered more comprehensive than the built-up area, a combination of band 4 (red spectrum) and band 5 (NIR/near-infrared spectrum) is used to obtain the logarithm of NDVI.

The next step is to classify land use using the classification of Malingreau (1978; Sari, 2022). In image processing, the land use classification uses supervised classification with data from a training area. This group of training areas represents a class of land cover, for example, forests, plantations, mixed gardens, and built-up areas. Furthermore, land use is classified using the maximum likelihood classification (MLC) by considering the probability factor of one pixel to be classified into a particular class or category. The choice of color combinations in this study chose the RGB: 652 combinations to determine the classification of land use with a bright green color representing diverse garden vegetation areas, while plantations with a dull green color. Forests appear dark green, cleared land has a magenta hue, and buildings appear purple to pink. In this combination, the body of water looks blue to dark blue.

Finally, an accuracy test is carried out, which aims to see the level of error that occurs in the area classification so that the percentage of mapping accuracy can be determined. The calculated accuracy test includes the user's accuracy, the producer's accuracy, overall accuracy, and Kappa. Total accuracy is valid based on Purwadhi (2001), in general, if it has an overall accuracy of more than 70% (Sari, 2022). The Kappa coefficient value has a range of 0 to 1. The Kappa index value considers the classification process error factor, so the Kappa index value is lower than the total accuracy value, which only considers the correct data between the classification results and field conditions. According to Congalton & Green (2008) that the value of the Kappa Coefficient and its accuracy level ranges from 0 - 0.4 (low), 0.4 - 0.8 (medium), and 0.8 - 1 (high) (Sari, 2022). The accuracy of mapping accuracy is done by making a confusion matrix. This accuracy test was conducted using a stratified random sampling method, with each class using 50 sample points. Furthermore, it analyzes spatial variations by overlaying land use change maps with administrative areas, slopes, accessibility, activity centers, and development centers.

RESULTS AND DISCUSSION

Image Analysis and Assessment of Classification Accuracy

Radiometric correction is carried out to eliminate or minimize atmospheric disturbances during the image recording process. Usually, this disturbance can be in the form of absorption, scattering, and reflection, which causes the pixel values in the recorded image to not match the pixel values of objects in the field. The calibration principle is to change the digital number (DN) value to a reflectance value. The radiometric correction process in this study was carried out by subtracting all digital numbers in the band with numbers that are at a minimum statistical value. The radiometric correction value from Landsat 8 imagery after the algorithm correction has been carried out that the minimum value for each band is 0 and the maximum value is 1 (Table 1).

Geometric correction is performed to correct geometric distortions to obtain images with the same projection and coordinate system. Geometric correction requires a surface control point or Ground Control Point (GCP). The accuracy of the placement of control points and the accuracy of geometric corrections can be seen from the RMS value. If the RMS value is close to zero, the point is considered correct (Purwadhi, 2011), but if the value is ≥1 pixel, the point must be corrected again. After each point has an RMS value of ≤1 pixel, the image becomes corrected. The results of the geometry correction carried out with 15 GCP points get an RMS error value of 0.00000 and show the correct results. To help visualize vegetation development, a combination of 652 bands can be used to highlight

Table 1. Radiometric Correction Results

Basic Stats	***Min***	***Max***	***Mean***	***Stdev***
Band 1	0.000000	1.000000	0.274334	0.305856
Band 2	0.000000	1.000000	0.252552	0.291377
Band 3	0.000000	1.000000	0.248579	0.292707
Band 4	0.000000	1.000000	0.24719	0.296323
Band 5	0.000000	1.000000	0.262665	0.289627
Band 6	0.000000	1.000000	0.029425	0.030847

Table 2. Confusion matrix for land use accuracy test in 2010

Kelas Tutupan Lahan	**Google Earth (tahun 2010)**								
	Forest	**Water Body**	**Mixed Garden**	**Empty land**	**Built-up area**	**Plantation**	**Shrubs**	**Total**	**User's accuracy**
Forest	**45**	-	3	-	-	2	-	50	90,0%
Water Body	2	**34**	-	-	-	-	14	50	68,0%
Mixed Garden	9	-	**27**	8	-	3	3	50	54,0%
Empty land	-	-	5	**38**	-	-	7	50	76,0%
Built-up area	3	3	23	9	**23**	-	2	50	46,0%
Plantation	6	-	9	8	-	**24**	3	50	48,0%
Shrubs	14	2	-	9	3	-	**22**	50	44,0%
Total	75	39		49	26		61	350	
Producer's accurac	57,0%	87,2%	40,3%	52,8%	88,5%	82,2%	43,1%		

Table 3. Confusion matrix for land use accuracy test in 2020

Kelas Tutupan Lahan	**Google Earth (tahun 2020)**								
	Forest	**Water Body**	**Mixed Garden**	**Empty land**	**Built-up area**	**Plantation**	**Shrubs**	**Total**	**User's accuracy**
Forest	**49**	0	0	0	0	1	0	50	98.0%
Water Body	3	**24**	0	9	0	0	14	50	48.0%
Mixed Garden	9	0	**31**	4	0	3	3	50	62.0%
Empty land	0	0	5	**34**	0	0	11	50	68.0%
Built-up area	3	0	3	0	**42**	0	2	50	84.0%
Plantation	3	0	9	6	0	**32**	0	50	64.0%
Shrubs	3	0	3	4	3	0	**37**	50	74.0%
Total	70	24	51	57	45	36	67	350	
Producer's accura(	70.0%	100.0%	60.8%	59.6%	93.3%	88.9%	55.2%		

agriculture and vegetation. Image processing and visual interpretation not only use true color (natural color) and false color image appearances but also uses NDVI as a comparison for the interpretation of vegetation development because of the nature of NDVI, which can highlight the appearance of vegetation.

Based on the interpretation of Landsat 8 imagery, the best band combination is used for land use classification. Observation of the correctness of land use objects visually in the field identified as seven land use, using supervised classification. The land use classes consist of forests, water bodies, built-up land, plantations, mixed gardens, and vacant land. The appearance of land use types in the image is displayed in different colors. Water bodies are represented in blue to dark blue. Vegetation is represented by light to dark green. The degree of brightness of this green color usually represents the vegetation's density and the incident light's angle when recording the image. High-density forests will appear dark green. The shrubs will look magenta to blue depending on the planting period in the field. Built-up land and open land are represented in purple to pink. The bare ground has a magenta hue. The land use classification results from Landsat 8 OLI data use the MLC (maximum likelihood classification).

The next step is to carry out an accuracy test to see the error level that occurs in the area classification. This accuracy test requires comparative data using interactive maps from Google™ Earth Pro. This accuracy test was conducted using a stratified random sampling

Table 4 . Ambon City land use area in 2010 and 2020

No.	Land use	The year 2010		The year 2020		Change	Ha
		Ha	%	Ha	%	Ha	average
1.	Forest	741.577	23.08	724,211	22.54	-17,366	-1,737
2.	Water Body	180.545	5.62	180.545	5.62	0,000	0,000
3.	Mixed Garden	1353.344	42.11	1186,412	36.92	-166,932	-16,693
4.	Empty land	56,626	1.76	25,974	0.81	-30,652	-3,065
5.	Built-up area	338,115	10.52	576,215	17.93	238.1 00	23,810
6.	Plantation	386,559	12.03	374,316	11.65	-12,243	-1,224
7.	Shrubs	156.730	4.88	145,823	4.54	-10,907	-1,091
	Amount	3213,496		3213,496			

method, with each class using 50 sample points. This accuracy test calculates the overall accuracy value and Kappa coefficient to determine the accuracy level. Table 2 and Table 3 show that the land use accuracy tests on the 2010 and 2020 images have Overall accuracy values of 73.4% and 71.1%, respectively. Based on Purwadhi (2001), the accuracy of a classification result is generally good if it has an overall accuracy of more than 70% (Sari, 2022). Meanwhile, Producer's and User's accuracy ranged from 40.3% to 100%. Furthermore, the Kappa coefficient is 0.68 and 0.61, and based on Congalton & Green (2008) show that the two accuracy tests are of moderate value (Sari, 2022).

Land use change in 2010 and 2020

The physical evolution of the land use types in the study area is dispersed and caused by various changes due to population activities. The classification in this study is based on Malingreau (1978) (Sitorus *et al.*, 2012). Moreover, the discussion under review focused on the extent of change in land use. Furthermore, based on an analysis of satellite imagery data, there has been a significant change between 2010 and 2020. This land use change data produces a spatial distribution map presented in Figures 1 and 2. Table 4 displays the area data for 2010 and 2020 and the degree of change.

Table 4 shows the shift in land use in Ambon City between 2010 and 2020 due to an increase in built-up area and a decrease in agricultural land area, especially vacant land, shrubs, mixed gardens, and forests. Residential land increased by 238.10 ha, and plantation land decreased by 12.243 ha (ha) between 2010 and 2020. Mixed gardening was the most extensive land use, decreasing by 166.932 ha, then the area of forest (17,366 ha), vacant land (30,652 ha), plantations (12,243 ha), and shrubs (10.907 ha) all decreased as a result of the changes. Changes over the last ten years (2010–2020) indicate a need for urban land, particularly for residential and built-up land in urban area development activities; this shift will add 23.810 ha per year, making it the most significant contributor to urban land. An increase in land area from built-up area causes a reduction in land area for other uses. This change is undeniable, the result of human activities encroaching on non-settlement land for development, resulting in a decrease in agricultural land (mixed gardens and plantations), which has experienced a shift in function. As described by Winoto et al. (1996), change in endangered use has occurred as a continuous process. Generally, changes that occur are socially, economically, politically, and culturally oriented (Sitorus *et al.*, 2012; Wicaksono & Hidayah, 2022).

Changes in land use based on spatial variations

Changes in land use for the 2010–2020 period were studied based on spatial variations based on administrative areas, slope, cultivation, protected areas, accessibility, activity centers, and development centers. Studies based on variations will be presented as follows. Changes in land use based on spatial variations in administrative areas show that there has been a decrease in forest area, most of which occurred in Ambon Baguala Bay District (6,614 ha). The decrease in the mixed garden area mainly occurred in Sirimau District (58,859 ha) and Ambon Baguala Bay District (43,452 ha). For vacant land, plantations, and shrubs, the decline in the land area mainly occurred in Ambon Bay District with an area of 4.110 ha, 3.989 ha, and 6.812 ha, respectively, and the spatial distribution can be seen in figure 3. Intensive land conversion occurred with additional investments, most of which occurred in the Sirimau District area of 76.880 ha, followed by the Ambon Bay area of 49,581 ha, the Ambon

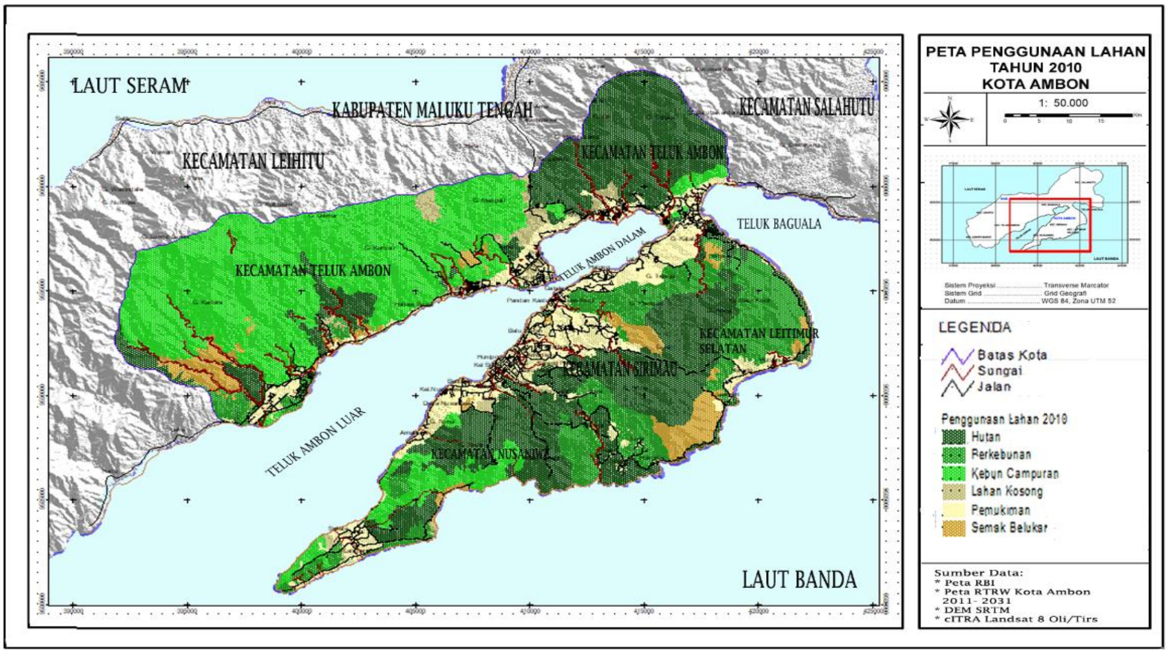

Figure 1. Ambon City Land Use Map in 2010

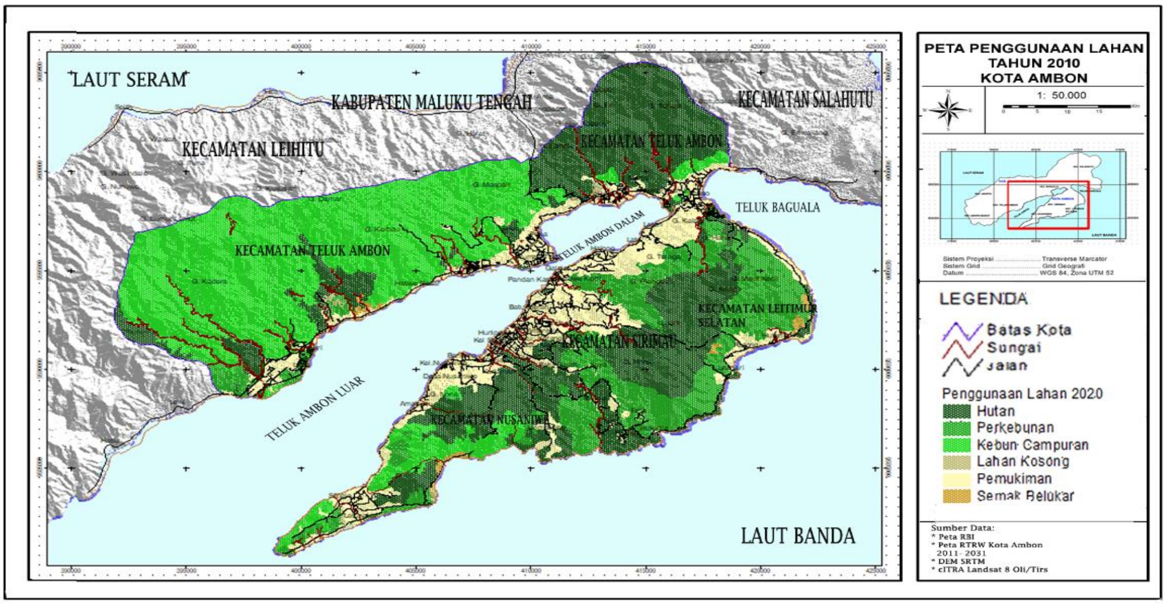

Figure 2. Ambon City Land Use Map in 2020

Baguala Bay area of 48,359 ha, and Leitimur Selatan with an area of 11,760 ha. The distribution of land area for each district is presented in Table 5.

The development of land conversion that has occurred is quite intensive in Sirimau District because this sub-district is a city center area with various city facilities and utilities that encourage various land uses for residents and in urban planning. Meanwhile, the changes in Teluk Ambon District were triggered by the existence of Pattimura University, which was a centrifugal factor that encouraged the development of new settlements built by the local community to be rented out to students. This land conversion is not only in terms of changing from one use to another but also related to changing the function of an existing building to another function about the commercialization of a place for business activities, restaurants, rentals, photocopying, and various other uses.

The development of land conversion that has occurred is quite intensive in Sirimau District because this sub-district is a city center area with various city facilities and utilities that encourage

Table 5. Area of change in land use per district in 2010 – 2020

No.	Land use	Subdistrict					Total Change
		Ambon Bay	South Leitimur	Nusaniwe	Sirimau	Ambon Bay Baguala	
1 .	Forest	-2.47 0	-0.711	-3,424	-4,147	-6,614	-17,366
2.	Mixed Garden	-20,782	-9.158	-34,681	-58,859	-43,452	-166,932
3.	Empty land	-28,613	0.06 0	-0.879	2.89 0	-4.11 0	-30,652
4.	Built-up area	49,581	11.76 0	43,359	76.88 0	56.5 0 2	238.1 00
5.	Plantation	-6,812	-2,764	-5,129	-1,819	4,281	-12,243
6.	Shrubs	-3,989	-0.76	-1,542	-2,282	-2,334	-10,907

Table 6. Area of change in land use based on slope

No.	Land use	Slope _					Total Change
		0 – 3%	3 – 8%	8 - 15%	15 – 30%	>30%	
1.	Forest	-3,435	-6,050	-6,693	-1,107	-0.081	-17,366
2.	Mixed Garden	-12,870	-78,748	-44,818	-23,242	-7,254	-166,932
3.	Empty land	-3,877	-7,503	-14,739	-4,109	-0.424	-30,652
4.	Built-up area	12,552	104,355	82,690	38,503	0.000	238.1 00
5.	Plantation	-2,521	-3,481	-4,764	-1,469	-0.008	-12,243
6.	Shrubs	-2,912	-1,984	-2,539	-2,061	-1,411	-10,907

Table 7. Area of change in land use based on protected areas and cultivation areas

No.	Land Use	Region		Total Change
		Protected area	Cultivation Area	
1.	Forest	-17,366	0.000	-17,366
2.	Mixed Garden	-36,268	-130,664	-166,932
3.	Empty land	-14,316	-16,336	-30,652
4.	Built-up area	16,505	221,595	238.1
5.	Plantation	-2,438	-9,805	-12,243
6.	Shrubs	-2,491	-8,416	-10,907

various land uses for residents and in urban planning. Meanwhile, the changes in Teluk Ambon District were triggered by the existence of Pattimura University, which was a centrifugal factor that encouraged the development of new settlements built by the local community to be rented out to students. This land conversion is not only in terms of changing from one use to another but also related to changing the function of an existing building to another function about the commercialization of a place for business activities, restaurants, rentals, photocopying, and various other uses.

Furthermore, changes in land use in terms of the slope aspect in Ambon City between 2010 and 2020 show that the direction of change in most built-up area increased the city's development. Most of built-up area were added on slopes of 3–8% and 8–15%, with an area of approximately 104,355 ha and 82,690 ha, respectively. This area experienced the most significant increase compared to other slopes because it became a destination for living due to its not-too-steep conditions, easy access to clean water, and accessibility to the main road. As a result of the expansion of built-up area, it has caused a reduction in land area, most of which occurs in plantation areas, with the most significant area occurring on slopes of 3–8% and 8–15%, each area covering an area of 78,748 ha and 44,818 ha, respectively. In addition, on this slope, there is also a reduction in forest area, namely an area of 6,050 ha and 6,693 ha. There was also additional built-up area on steep slopes (15-30%) covering an area of 38,503 ha, with the majority converting the use of mixed garden land covering an area of 25,242 ha and vacant land, shrubs, and forests covering a smaller area.

The slope is one of the factors causing various changes in land use; many residents occupy relatively flat areas compared to steep areas, which require additional work in covering the soil before development activities (Kubangun *et al.,* 2019). Various land-use changes on this slope can be seen

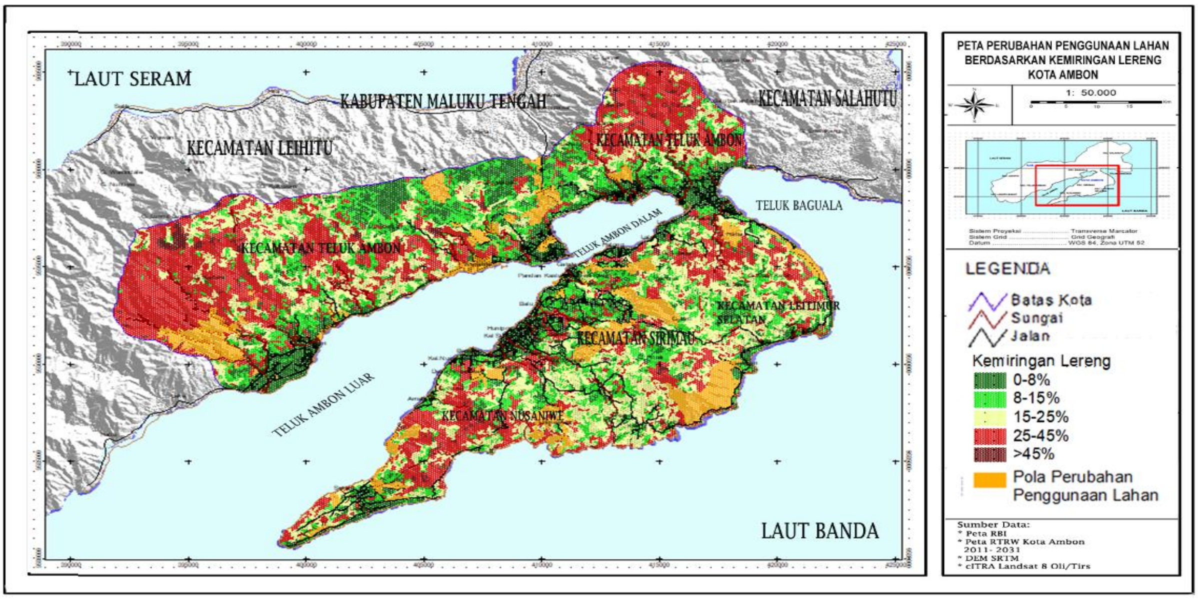

Figure 4. Changes in Land Use on Slopes

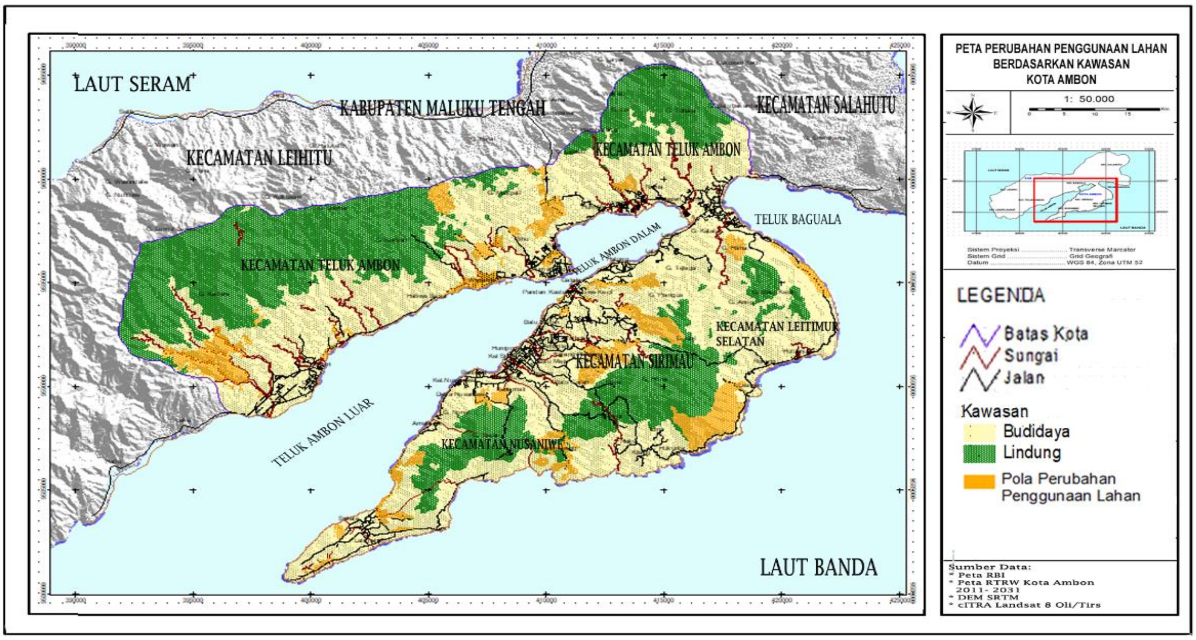

Figure 5. Changes in Land Use in Protected Areas and Cultivation Areas

in Table 6, and the spatial variations can be seen in Figure 4.

Based on the spatial variation of cultivation areas and protected areas in Ambon City. Table 4 shows the addition of residential areas. With a change in the area of 221,595 ha, most of it dominates cultivated areas. In addition, there has also been an increase in land use protected areas, covering an area of 16,505 ha. A mixed garden area of 130,664 ha is the most significant contributor to the decline in land use in cultivation areas, around 17,366 ha. Furthermore, there has been an increase in built-up area-protected areas covering an area of 16,505 ha and a decrease in forest land area of 17,366 ha.

Based on spatial variations in the location of urban activity centers in Ambon City between 2010 and 2020, there has been an increase in built-up area in the city center, covering an area of 132,901 ha, and the inner-city membrane, covering an area of 87,909 ha. This change was triggered by the neighborhood's proximity to the city center and main roads. The mixed-garden area experienced the most significant decrease in land use in the city center area of 97,182 ha and the city core area of 59,190 ha. In addition, about 6,370 ha of shrubs

Table 8. Area of change in land use based on the location of activity centers

No.	Land use	Hub			Total Change
		City center	City Core	Suburbs	
1.	Forest	-3,966	-8,520	-4,880	-17,366
2.	Mixed Garden	-97,182	-59,190	-1 0.560	-166,932
3.	Empty land	-3,632	-26,980	-0.040	-30,652
4.	Built-up area	132,901	87,909	1 7.290	238.1
5.	Plantation	-1,303	-6,760	-4,180	-12,243
6.	Shrubs	-1,907	-2,630	-6,370	-10,907

Table 9. Area of change in land use based on the development

No.	Land use	Center				Total Change
		Primary	Secondary 1	Secondary 2	Tertiary	
1.	Primary Forest	-2,893	-6,614	-4,020	-3,839	-17,366
2.	Mixed Garden	-16,803	- 36,452	-41,609	-72,068	-166,932
3.	Empty land	-3,804	-9,110	-11,678	-6,060	-30,652
4.	Built-up area	86,520	76,526	43,304	31,750	238.1
5.	Plantation	-0.978	-5,281	-3,220	-2,764	-12,243
6.	Shrubs	-3,441	-4,334	-2,592	-0.540	-10,907

decreased as a result of the agricultural activities of residents in suburban areas. In comparison, vacant land experienced a reduction of 26,980 ha in the inner-city membrane area. Various changes in land use in the activity center area are shown in Table 8.

In the suburbs, there has been a change with an area of 17,290 ha, and land reduction occurred mainly on 10,560 ha of forest land, 4,880 ha of forest, and 6,370 ha of shrubs, all still dominated by undeveloped land use. This land shrinkage is due to the activities of people engaged in the agricultural sector in changing land, such as vacant land and shrubs, for their agricultural activities. Apart from that, it is also for developing settlements for the local population. The occurrence of land conversion in suburban communities also contributes significantly.

Based on development centers in Ambon City, Table 9 shows land-use changes experienced an increase in residential land area in the primary center, around 86,520 ha, and the secondary center I covering 76,526 ha. The expansion built-up area have caused most of the land reduction to occur in secondary centers, both in the mixed-garden area of 36,452 ha, the vacant land area of 11,678 ha, the shrub area of 4,334 ha, and the forest area of 6,614 ha. Primary centers represented a reduction of 16,803 ha of mixed garden land, 3,804 ha of empty land, 3,441 ha of shrubs, and 2,893 ha of forest. This intensive change was caused by increased activity in the economic sector, which led to the development of this area.

The development of a region will affect the spatial planning that the local government has prepared based on the physical, social, and cultural characteristics of regional services. This fact is relevant in the context of infrastructure alone and comprehensively covers institutional capacity, human resource development, and the economy. In addition, an increase in units and varieties of city facilities and infrastructure supports regional development in the context of service centers supporting community activities (Nuraeni *et al.*, 2017).

CONCLUSIONS

Changes over the past ten years (2010–2020) indicate an urban land need, especially for residential and built-up land in urban area development activities. This shift will add another 23.810 ha per year and make it the most significant contributor to urban land. Mixed gardening is the most extensive land use, which has decreased by 166.932 ha, followed by forest area (17,366 ha), vacant land (30,652 ha), plantations (12,243 ha), and shrubs (10.907 ha). Spatial variation based on administrative area is dominated by the addition of built-up area in Sirimau District with an area of 76.880 ha, followed by the most significant reduction in land area in mixed gardens with an area of 58.859 ha. On the slope, there is an addition to these built-up area, dominated by slopes of 3–8% and 8–15%. In addition, there were additional built-up area on steep slopes (15–30%) covering an area of 38,503 ha by converting land use, which was dominated by mixed gardens with an area of 25,242.

In cultivation and protected areas, there was an addition of residential areas, which were dominated in cultivation areas but also occurred in protected areas, covering an area of 16,505 ha with a reduction of 17,366 ha of forest land. Location of the center of activity: there is an increase in built-up area in the city center and the inner-city core. In contrast, the relatively small increase in built-up area in suburban areas was 17,290 ha. Accessibility and land use expansion dominated built-up area (116,370 ha) with a radius of 3 km and a 3-5 km area of 88,500 ha. The most significant reduction in the land area was in mixed gardens, with an area of 53,150 ha and 14,132 ha, respectively. In development centers, there was an increase in residential land area in primary centers of around 86,520 ha and secondary center I of 76,526 ha. The expansion of this built-up area has caused most of the land reduction to occur in secondary centers in mixed gardens with an area of 36,452 ha.

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