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MAPPING OF LAND USE CHANGES AND ALIGNMENT OF SPATIAL PATTERN PLANS IN PADANG CITY

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ABSTRACT: Changes in land use in accordance with spatial pattern plans are a challenge for the government as the population in an area increases, resulting in increased land requirements. This greatly influences the spatial pattern plans that have been planned previously. These land use changes can be obtained from Remote Sensing data which has the advantage and ease of obtaining land use information. This research uses Sentinel-2A satellite image data for 2017 and 2023. The objectives of this research are (1) To determine the ability of Sentinel-2A imagery to interpret land use (2) To determine changes in land use in 2017 and 2023 (3) To find out the alignment of land use identification with the Padang City spatial pattern plan. The method used in this research is a quantitative method with an approach spatial (spatial approach). The method used for land use classification is the manual digitization method (on screen) and land use area calculation using the Geometry Calculator tool in ArcGIS 10.6.1 software. The research results show the ability of Sentinel-2A imagery to produce 15 land uses, namely highland forest, residential/mixed buildings, rivers, cultivated open land, rice fields, dry land seasonal crops, bushes and thickets, mining, runways, ports, buildings industry and trade, grass, mangrove forests, savannas and stretches of coastal sand. In a period of 5 years there were 13 land uses that experienced changes, namely highland forests, residential/mixed buildings, open cultivated land, bushes and shrubs, mining, industrial/commerce buildings, dry land seasonal crops, rice fields, mangrove forests, stretches of beach sand and grass. The harmony between the land use of Padang City and the Padang City Spatial Pattern Plan is dominated by harmony, but there are also those which are not in harmony, namely highland forests, residential/mixed buildings, rice fields, dry land annual crops and mining.

Keywords: Land Use Change, Spatial Pattern Harmony, On Screen Digitization, Remote Sensing, Sentinel-2A Imagery.

1. INTRODUCTION

Land is very important for living creatures, especially humans, who really need land to cultivate in order to meet life's needs. The physical environment of land, water, flora and fauna, and climate is called land. For humans, land cultivation usually takes the form of land use. Land use is every form of human intervention on land in order to fulfill their life needs, both material and spiritual (Jamulya and Sunarto, 1995). The demand for land increases as the population in an area increases over time, which threatens land availability. This is because humans ignore the suitability of the land they work on for their own needs and interests.

Human activities that carry out irregular land management cause changes in land use which in turn lead to land conversion which ultimately has a negative impact on humans themselves. With the passage of time and careless land management, the amount of land used for survival will continue to decrease. In an effort to organize, control and plan in an area, the government has regulated planning through spatial patterns that distribute space in an area. The spatial pattern plan includes two spatial functions, namely cultivation function and protection function. However, this sometimes contradicts the plans that have been made and determined by the government.

Padang City is the capital of West Sumatra Province which has an area of 69,500 ha with a population based on Central Statistics Agency (BPS) data of 909,040 people. Astronomically, Padang City is located at 0°44'00"-1°08'35" South Latitude and 100°05'05"-100°34'09" East Longitude. Geographically, Padang City borders Padang Pariaman Regency to the North, to the East Padang City borders Solok City and Solok Regency, to the South Padang City borders Pesisir Selatan Regency and to the West Padang City borders the Indian Ocean. There are 11 sub-districts and 104 sub-districts in Padang City.

The role of remote sensing is to help see land changes that are not in accordance with planned spatial patterns

without having to come into direct contact with objects in the field. The data used is in the form of the latest satellite imagery which makes it easier to identify land changes and align spatial pattern plans in Padang City. Apart from that, GIS (Geographic Information System) also helps in obtaining information in the form of objects and locations on the earth's surface. Changes in land use can be monitored through remote sensing data in the form of satellite imagery which is capable of detecting, identifying and interpreting land use by including elements of image interpretation. The type of satellite imagery used to monitor land use changes is Sentinel-2A imagery developed by Copernicus Europe. This satellite was launched in 2015 and has 13 bands whose spatial resolution is divided into 3 bands having a spatial resolution of 60 meters, 6 bands having a spatial resolution of 20 meters and 4 bands having a spatial resolution of 10 meters.

The aim of this research was to determine the ability of Sentinel-2A imagery to interpret land use and to determine changes in land use from 2017 to 2023 in Padang City and to determine the harmony between Padang City's land use and Padang City's spatial pattern plan for 2010-2030.

2. RESEARCH METHODS

2.1 Time and Place of Research

When this research was conducted in 2023, it took place in the Padang City area, West Sumatra Province.

2.2 Research Instrument

The type of research in this final assignment is quantitative research with a spatial approach which presents land change information using remote sensing and GIS (Geographic Information System). The data used is secondary data in the form of medium resolution satellite imagery, namely the 2017 and 2023 Sentinel-2A images downloaded on the Copernicuss website.

2.3 Data Processing Stages

2.3.1 Preprocessing

This stage, through radiometric correction, aims to correct pixel values that do not match the spectral radiance of the object on the earth's surface and improve the visual quality of the digital image. After preprocessing the Sentinel-2A image, the next stage is cropping the radiometrically corrected image. This cutting was carried out using ArcGIS software using the tools in ArcToolbox, namely Data Management Tools. In Data Management Tools there are many menus for image processing, however, for the image cropping menu, it is in the raster menu, then select clip.

2.3.2 Processing

In processing this data, visual interpretation is used with the help of Google Earth Pro software. This image interpretation aims to recognize objects in the image in terms of their visible shape and appearance. To recognize an object, there are 8 elements of interpretation, namely, hue, shape, size, texture, pattern, shadow, site and association. After interpreting the image and finding the land use object, the next stage is delineating the object. The method used for this delineation is using the manual digitization method (on screen).

2.3.2 Classification scheme

The land use classification scheme refers to the land cover classification of SNI (Indonesian National Standards) part 1 for small and medium scale. The Sentinel-2A image is 10 meters (with a scale of 1:100,000) which is classified as a medium resolution image. However, in the land cover classification of SNI (Indonesian National Standards) there is no scale of 1:100,000, adaptations have been made to the existing scales, namely, scales of 1:250,000 and 1:50,000.

2.3.3 Sampling Techniques

At this stage of sampling, sampling is carried out in definite land use areas using a purposive random sampling method. The purposive random sampling technique is a technique for determining and taking samples determined by researchers with certain considerations (Sugiyono 2015, in Maharani & Bernard 2018).

The use of the Slovin algorithm is commonly used in research with large population objects, resulting in large samples. The Slovin formula states that the sample is part of the number and characteristics of the population. Determining the number of samples is one of the steps in

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determining how many samples will be taken when conducting research on an object (Sugiyono, 2015 in Rosyi & Mardianta, 2021). Below is Slovin's algorithm.

$$n = \frac{N}{1+Ne^2}$$

Information :
n = Number of samples
N = Number of population
e= The amount of error tolerance when determining the sample is a maximum of 5%.

2.3.4 Accuracy Test

The accuracy test aims to determine the accuracy of the data used in this research. The classification results from image interpretation will be subjected to an accuracy test which aims to see the accuracy between the results of land use classification through image interpretation and objects in the field (Thomas M. Lillesand 1993, in Soma, et al, 2021). In the level of accuracy, contingency matrices or error matrices (Confusion matrices) are used. Error matrices (Confusion matrices) are calculations of each error in the form of land use from the classification results in the image.

2.3.5 Field survey/ground check

The field survey/ground check stage was carried out in 2 different ways on the two images. Firstly, a ground check was carried out on the 2017 sentinel imagery using Google Earth Pro software, where one of the features of Google Earth Pro, namely historical imagery, is useful for viewing image data from previous years. Sampling using Google Earth Pro software is based on sample points that have been distributed to each land use class. This distribution of sample points has been determined at the sampling technique stage and is necessary for accuracy testing. Second, on the 2023 Sentinel-2A imagery, a ground check was carried out directly on land use objects.

2.4 Data analysis technique

2.4.1 Land Use Overlay

The overlay was carried out in ArcGIS software using geoprocessing tools, namely intersect. Changes in each land use class are known through the field calculator process, where these changes are based on changes in land area from 2017 to 2023. The calculation of the land area that has experienced changes is known through the geometry calculator tool

2.4.2 Space Pattern Alignment Overlay

Combining the land use of the City of Padang for the latest year with the spatial pattern plan for the City of Padang was carried out using ArcGIS 10.6.1 software. by using geoprocessing tools, namely intersect. The alignment between the latest land use of Padang City and the planned spatial pattern of Padang City is known through the field calculator process. The results of the overlay of the land use of the City of Padang for the latest year with the spatial pattern plan for the City of Padang for 2010-2030 will be divided into 2 groups, namely the built group and the non-built group.

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2.5 Research Flow Chart

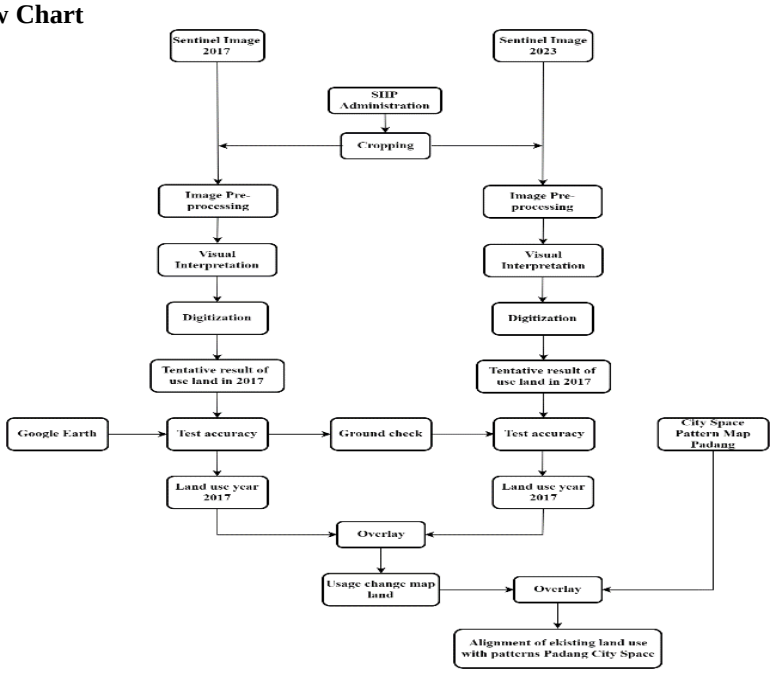

Figure 1. Research Flow Diagram

3. RESEARCH RESULTS AND DISCUSSION

3.1 Land Use Classification

There are 2 year series of land use classifications obtained from Sentinel-2A imagery in 2017 and 2023.

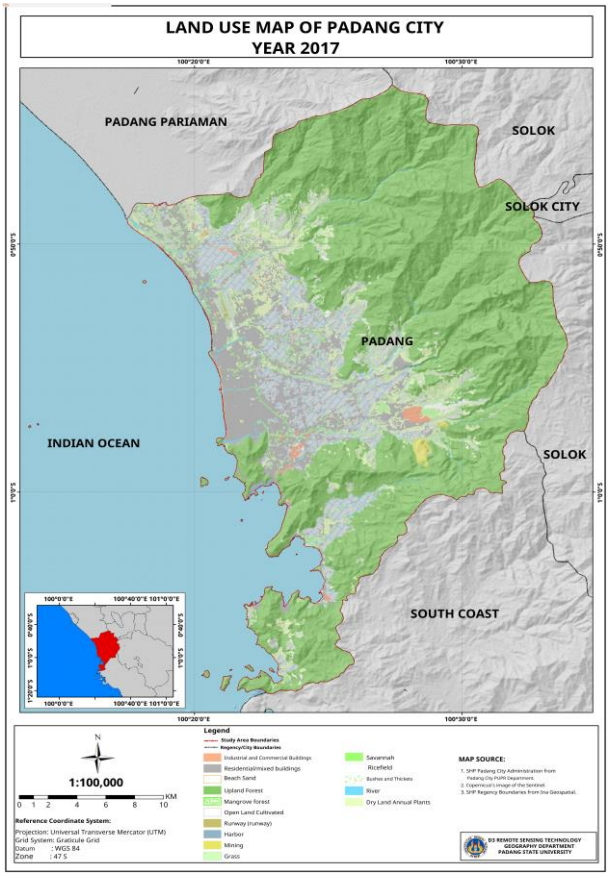

Figure 2. 2017 Land Use Map

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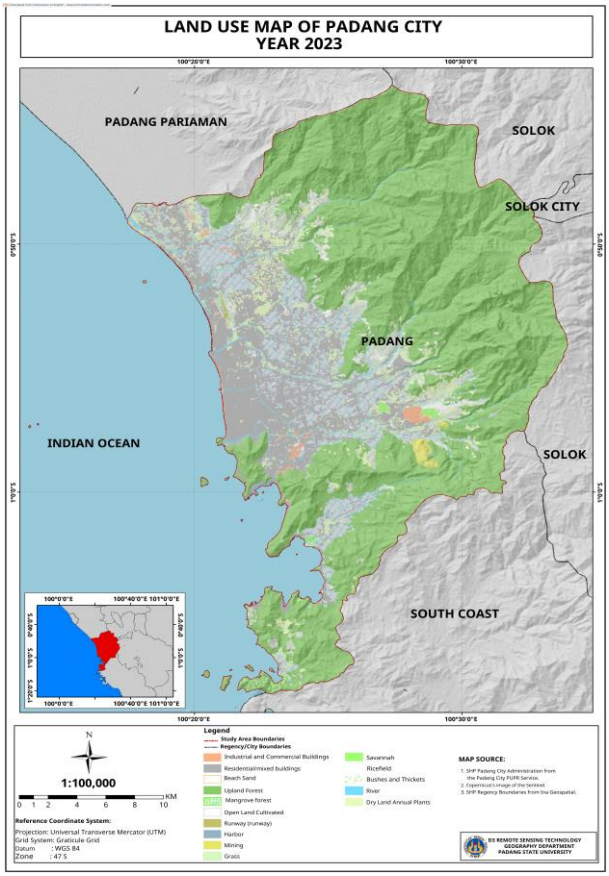

Figure 3. Land Use Map in 2023

Land use classification in Padang City in 2017 and 2023 uses the manual digitization method (on screen) on remote sensing data, namely Sentinel-2A satellite imagery in 2017 and 2023 which has a spatial resolution of 10 meters and is assisted by 8 elements of image interpretation which are useful for recognizing objects that appear in the image. There are 15 land use classes from the results of land use classification in Padang City, namely, highland forest, residential/mixed buildings, cultivated open land, bushes and thickets, dry land seasonal crops, mining, runways, ports, rice fields, buildings industry and trade, rivers, mangrove forests, stretches of beach sand, grass and savanna.

Table 1. Land use area

Land Use	Area (Ha)	
	2017	2023
Upland Forest	44405.62	44198.41
Industrial and Commercial Buildings	401.62	405.7
Grass	72.52	71.71
Harbor	70.99	70.99
Open Land Cultivated	663.16	563.62
Residential/Mixed Buildings	8823.63	9151.74
Mining	206.65	265.75
Ricefield	6210.68	5772.09
River	543.24	545.05
Runway (runway)	31.25	31.25
Savannah	107.51	107.51
Dry Land Annual Plants	3383.86	3310.87
Bushes and Thickets	4750.03	3307.2
Mangrove forest	68.4	67.95
Beach Sand	28.7	25.86

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3.2 Land Use Change

3.2.1 Changes in Land Use from 2017 to 2023

Based on the results of land use classification in Padang City over a period of 6 years, namely from 2017 to 2023, there are changes in land use that have occurred. This change in land use takes the form of reducing and increasing the area from one land use to another, which is usually called land conversion. Changes in the area of land use can be determined using the land use change matrix.

Table 2. Land Use Change Matrix for 2017 and 2023

Class		2017															Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
2023	1	402.29															420.29
	2		8823.63														8823.63
	3			24.35										2.76	1.52		28.63
	4		12.97		44137.21		18.68										44198.41
	5		0.44			67.95				29.55							68.39
	6		8.88				563.62							110.5		10.75	693.75
	7							31.25									31.25
	8								70.99								70.99
	9									236.2							236.32
	10		1.86								72.52						74.38
	11											107.5					107.5
	12	1.36	204.9				10.09						5772.09				6210.68
	13	1.97	58.3				115.73							4756.38		3.46	4932.38
	14														543.53		543.52
	15	1.02					9.34									3310.87	3362.04
	Results	406.64	9151.74	24.35	44137.21	67.95	717.46	31.25	70.99	265.75	72.52	107.5	5772.09	4869.64	545.05	14.21	69579.92

Information:

Industrial and Commercial Buildings = 1
Residential/Mixed Buildings = 2
Beach Sand Expanse = 3
Upland Forest = 4
Mangrove Forest = 5
Open Land Cultivated = 6
Runway (runway) = 7
Harbor = 8
Mining = 9
Grass = 10
Savannah = 11
Rice fields = 12
Shrubs and Thickets = 13
River = 14
Dry Land Annual Plants = 15

The results of the classification of land use changes from 2017 to 2023 in the City of Padang show that the change in highland forest has an area of 44137.21 ha (hectares) which has changed to 44198.41 ha (hectares), the stretch of beach sand has an area of 24.35 ha (hectares) which has changed to 25.86 ha (hectares), mangrove forests had an area of 68.4 ha (hectares) changed to 67.25 ha (hectares), open land cultivated had an area of 563.62 ha (hectares) changed to 563.62 ha (hectares), paddy fields have an area of 6210.68 ha (hectares) which has changed to 5772.09 ha (hectares), grass has an area of 72.52 ha (hectares) which has changed to 71.71 ha (hectares) of bushes and shrubs has an area of 4756.38 ha (hectares) experiencing a change of 3307.2 ha (hectares) and dry land annual plants have an area of 3310.87 ha (hectares) experiencing a change of 3310.87 ha (hectares).

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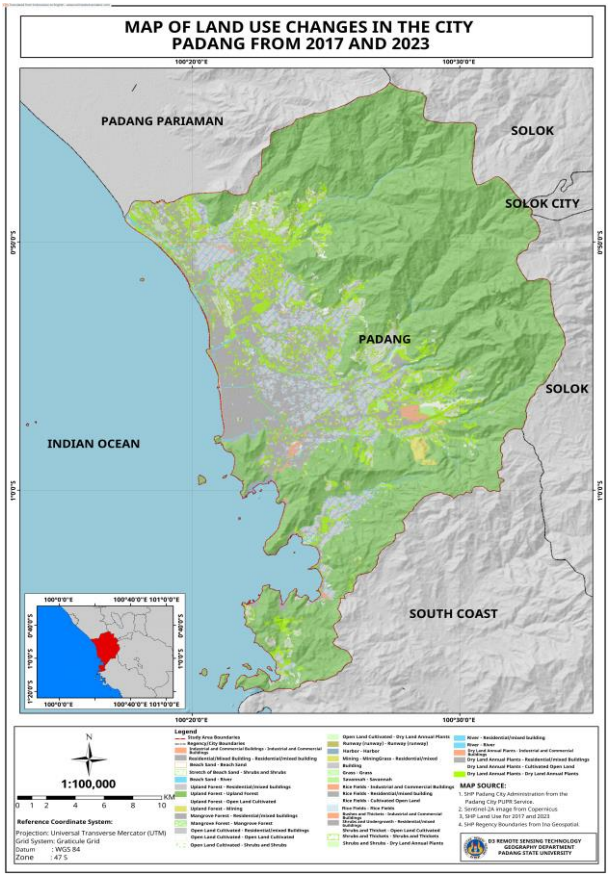

Figure 4. Changes in land use from 2017 to 2023

3.2.2 Accuracy Test

In the statement of Thomas M. Lillesand (1993), in Soma, et al (2021) that the accuracy test for image classification is accepted with a minimum level of accuracy, namely 85%. If the accuracy test gets results below 85%, then the land use classification cannot be said to be accurate and the classification must be repeated. To determine the number of samples for each land use, the Slovin algorithm is used. The following is the calculation of the number of samples using the Slovin algorithm:

$$n = \frac{N}{1+Ne^2}$$

$$n = \frac{69.500}{1+69.500\ (0{,}05 \times 0{,}05)}$$

$$n = \frac{69.500}{17.376}$$

n = 40 samples

Table 3. Distribution of sample points

Land use	Sample Point
Upland Forest	6
Residential/mixed buildings	5
Beach Sand	1
Mangrove forest	2
Ricefield	5
Open Land Cultivated	5
River	1
Dry Land Annual Plants	4
Savannah	1
Bushes and Thickets	5
Grass	1
Runway (runway)	1
Mining	1
Harbor	1
Industrial and commercial buildings	1
Amount	40

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Determining the confusion matrix value for land use in 2017 and 2023 was carried out in several stages, namely user's accuracy, producer accuracy, overall accuracy and Kappa index.

Table 4. 2017 Confusion Matrix

Class	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Producer accuracy
1	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6
2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	4
4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
5	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
6	0	0	1	0	0	4	0	0	0	0	0	0	0	0	0	5
7	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	5
8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
9	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	4
10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
14	0	0	1	0	0	0	0	0	0	0	0	0	0	4	0	5
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
User Accuracy	5	2	6	1	2	5	5	1	3	1	1	1	1	5	0	40

From the results of determining the accuracy value using the 2017 confusion matrix, the calculation of the overall accuracy and Kappa index shows that based on the sample points distributed in each land use class the overall accuracy value is 87.5% and the Kappa index value is 86.16 % of the total sample, namely 40 sample points.

Table 5. Confusion Matrix in 2023

Class	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Producer accuracy
1	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6
2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	4
4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
5	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
6	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5
7	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	5
8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
9	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	4
10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
14	0	0	1	0	0	0	0	0	0	0	0	0	0	4	0	5
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
User Accuracy	5	2	5	1	2	5	5	1	3	1	1	1	1	6	0	40

Information:

High land forest = 1
Industrial and trade buildings = 2
Residential/mixed buildings =3
Beach sand expanse = 4
Mangrove forest = 5
Rice fields = 6
Open land cultivated = 7
River = 8
Dry land annual plants = 9
Savannah = 10
Mining = 11
Runway = 12
Harbor = 13
Thickets = 14
Grass = 15

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From the results of determining the accuracy value using the 2023 confusion matrix, the calculation of the overall accuracy and Kappa index shows that based on the sample points distributed in each land use class the overall accuracy value is 90% and the Kappa index value is 88.95% of The total sample is 40 sample points.

3.3 Harmony of Spatial Patterns

Determining the harmony between land use and the spatial pattern plan is based on the overlap between land use and the spatial pattern plan. If the land use that overlaps between land uses is in accordance with the specified spatial pattern plan, it can be said to be harmonious. If the overlapping land uses are not in accordance with the specified spatial pattern plan, it can be said to be incongruent.

Table 6. Alignment of Land Use with Padang City Spatial Pattern Plan

No	Name	Aligned/Not Aligned	Area (ha)
1	Cultivation Area -runway	Aligned	31.25
2	Protected areas -Highland forests	Aligned	42,702
3	Protected areas -Residential/mixed buildings	Not Aligned	62.27
4	Protected areas-Dry land annual plants	Not Aligned	10.22
5	Protected areas - Open Land is encouraged	Aligned	222.33
6	Protected areas -Mining	Not Aligned	4.29
7	Protected area -Grass	Aligned	110.94
8	Protected area -Paddy fields	Not Aligned	166.46
9	Protected areas -Shrubs and Scrubs	Aligned	2,674
10	Protected area -River	Aligned	549.05
11	Protected area- Residential/mixed buildings	Aligned	42.25
12	Cultivation Area -Highland Forest	Aligned	171.61
13	Cultivation Area -Highland Forest	Not Aligned	1,541
14	Cultivation Area – Industrial and trade buildings	Aligned	401.80
15	Cultivation Area - Residential/mixed buildings	Aligned	8,669
16	Cultivation Areas - Open Land is encouraged	Aligned	505.92
17	Cultivation Area - Harbor	Aligned	70.99
18	Cultivation Area - dry land annual crops	Aligned	2,592
19	Cultivation Area - Mining	Aligned	232.13
20	-Grass Cultivation Area	Aligned	163.34
21	Cultivation Area - Rice Fields	Aligned	5,833
22	Cultivation Area - Shrubs and Shrubs	Aligned	3,195
23	Protected Area-Mangrove Forest	Aligned	4.32
24	Protected Area - Beach Sand	Aligned	17.85
25	Protected Area-Savanna	Aligned	107.58
26	Cultivation Area-Savanna	Aligned	95.81

Land uses that are in line with the spatial pattern plan include runways, production forests, ports, residential/mixed buildings, industrial and commercial buildings, dry land seasonal crops, rice fields, mining, open land for use, grass, mangrove forests, stretches of beach sand, savanna and savanna. However, from the results of the alignment between the land use of Padang City and the spatial pattern plan of Padang City, there are land uses that are not in harmony with the spatial pattern plan, including highland forests, residential/mixed buildings, mining, dry land seasonal crops and rice fields. There are 3 land uses that can be included in protected areas and can also be included in cultivation areas. The land uses in question are shrubs and thickets, open cultivated land and grass. This is influenced by the location of the land use, where bushes and open land are unused land uses, while grass is usually found in residential areas, airports and also in green open space areas.

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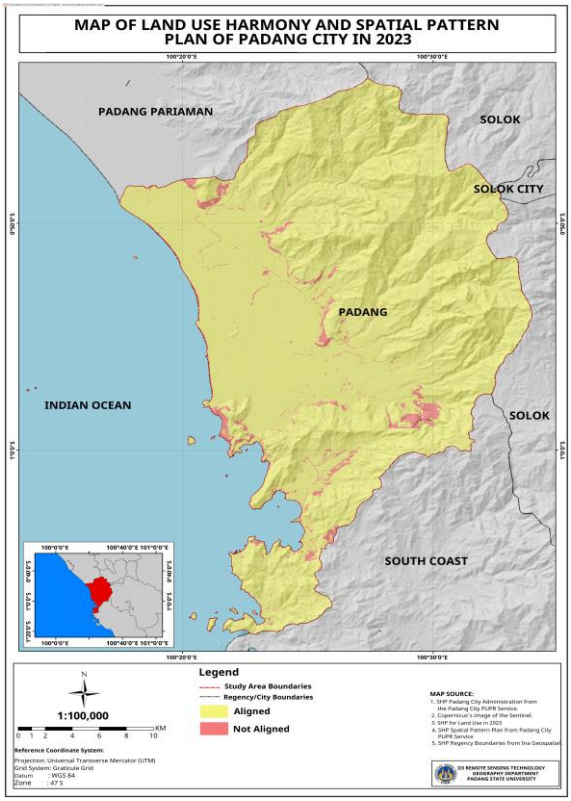

Figure 5. Map of Harmonization of Land Use and Spatial Pattern Plan

From the results of aligning the land use of Padang City with the spatial pattern plan of Padang City, it is divided into 2 areas, namely non-built and built-up. This division is based on a combination of the spatial patterns of protected areas and cultivation areas. The aim is to group the results of alignment between land use and spatial pattern plans based on built and non-built areas.

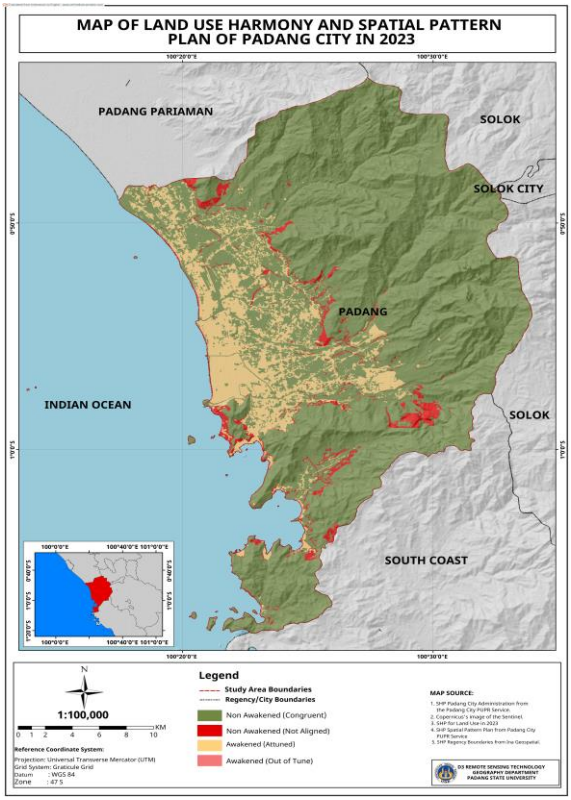

Figure 6. Map of Land Use Alignment with Spatial Pattern Plans Based on Built-up and Non-Built-Up Areas.

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4. CONCLUSION

The ability of the Sentinel-2A image to classify land use in Padang City using the manual digitization method (on screen) resulted in 15 land use classification classes consisting of highland forest, residential/mixed buildings, cultivated open land, bushes and thickets, dry land annual plants, mining, runways, ports, rice fields, industrial and commercial buildings, rivers, mangrove forests, stretches of beach sand, grass and savanna. From the results of land use classification in Padang City from 2017 to 2023 using the manual digitization method (on screen) of 15 land use classes, it was found that 13 land use classes experienced changes, namely highland forest, residential/mixed buildings, cultivated open land, bushes. and shrubs, mining, industrial/commerce buildings, dry land annual plants, rice fields, mangrove forests, stretches of beach sand and grass. There are 2 land uses that have not changed, namely runways and ports. The harmony between the land use of Padang City and the spatial pattern plan of Padang City is dominated by harmony. However, there are still land uses in Padang City that are not in line with Padang City's spatial pattern plan, namely highland forests, residential/mixed buildings, rice fields, dry land seasonal crops and mining.

5. REFERENCE

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