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SOIL/LAND USE CHANGES AND URBAN SPRAWL IDENTIFICATION IN PANDAAN DISTRICT, INDONESIA

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ABSTRACT: The phenomenon of urban sprawl is a serious problem worldwide for the environmental and socio-economic reasons. Land used change from agricultural land to others activities like settlements, industrial used, and infrastructure development is common in urban rural relation. Pandaan District that located near Surabaya City and in the main road to Malang city have the indication of urban sprawl. Urban Sprawl is a phenomenon that occurs from fast city development but has limited land, thus pushing the population to the suburban areas and even outside the area of the main city. This research aims to determine the pattern of land use change and identify urban sprawl based on patterns of land use changes from 2010 to 2018. We use GIS methods that could process spatial analysis using multi-temporal satellite imagery (time series data) of the study area. The results of the analysis with GIS conclude that the land use change in Pandaan District from 2010 to 2018 the highest change in non-built-up land use is wetland/paddy fields. The change is from 2789.21 hectare in 2010 to 2575.52 hectare in 2018 or decreases 213.69 hectare. Related to the identification of urban sprawl, there are eight villages identified as having experienced sprawl, that is Plintah village, Durensewu village, Karangjatim village, Wedoro village, Tawangrejo village, Nogosari village, Kemirisewu village, and Banjarsari Village.

Keywords: *Land use change, Settlement, Urban sprawl, Soil*

1. INTRODUCTION

Soil and land cannot be distinguished nowadays. The use of soil and land will always be linked to human activities. Urban, rural and isolated communities across the globe have many land requirements. Land needed for the supply of food, feed, fiber and fuel (including biofuels); regulation and infrastructure; environmental services; and the use of metals and minerals.

Earth's land or soil ability, aquatic, and nutritional systems have been limited to meet human needs. It is consists of population growth, environmental degradation, and degradation of soil quality, climate change, food, urbanization, waste, and loss of supply chain, global trade and the existence of urban sprawl.

The phenomenon of urban sprawl is a serious problem worldwide for the environmental and socio-economic reasons. This has been a major challenge in terms of sustainable land use, and this is a concern for the International Years of Soil 2015. In 2008, half of the planet lived in urban areas where agglomeration and proportion continued to increase [1]-[2]. The population increase will displace the population living in cities that are moving towards the city of expansion to suburb or rural area [3]-[4]. The use of fertile farmland in the suburb is inevitable, where many lands have been used for urban sprawl [5].

The district of Pandaan, located along the main artery road between Surabaya Malang and near from the City of Surabaya, is also experiencing a phenomenon of urban sprawl. In the Spatial Planning Profile Document of East Java province 2015 [6], Pandaan District included in the corridor of the Strategic Economic Region. The result of the program is an increase in built-up land demand, thus increasing land use change from non-built-up lands to built-up land.

The increase in built-up lands is also driven by the development of residential areas to the areas of Pandaan District, as a result of the development of Surabaya City where the limited land availability causes high land prices. Another cause is the development of Industrial estate. It can accelerate economic growth and, in the long term, reduce poverty [5] and [7]. Functioning as an "engine of economic growth," it generates rapid economic growth that can increases urban populations, triggering encroachment and urban sprawl [5] and [8], which can damage agricultural land and activities of the farmers. This encouraged the development of built-up lands in Pandaan District identified as sprawl.

The identification of urban sprawl and land used change could use spatial analysis methods using a geographic information system (GIS) approach. GIS could help to process spatial

analysis using multi-temporal satellite imagery (time series data) of the study area. Spatial analysis is more focused on identifying development patterns and the level of land use change and the development of sprawling, which is then observed by conducting a field survey to check the existing conditions of land use. The aims of this study are: 1) To identify urban sprawl typology; and 2) What is the effect of urban sprawl on land use change in the research area.

2. METHODS

This research is located in Pandaan District, Pasuruan Regency. The object of this research is the land cover from 2010 to 2018 and the identification of Urban Sprawl.

The land use change data in 2010 and 2018 are used as input data to analyze land use change and identify the type of sprawl development until 2018 [9].

Spatial analysis is to analyze the level of land use change, and the classification of sprawl is done using the Geographic Information System (GIS) approach with the GIS tool, ArcGIS.

The data used in this study are:

- LANDSAT 2010 Satellite Imagery from USGS,
- LANDSAT 2018 Satellite Imagery from USGS,
- Slope and Topography, from 1-meter contour elevation data interval (DEM), from Development Planning Board of Pasuruan Regency (BAPPEDA), USGS and Global Mapper,
- Building density from secondary data,
- Main road data from the Pasuruan BAPPEDA (Development Planning Board of Pasuruan Regency)
- Regional structure vector data (Central Business District and Settlement Center) from (Development Planning Board of Pasuruan Regency) BAPPEDA.

Satellite imagery is then interpreted to become land use information. The classification of land use utilizes a modified classification [10]. The basic modification of this classification is to look at the characteristics of the study area. This land's classification is divided into five classes of land use, namely built-up land consisting of the residential and industrial area and non-built-up land in the form of paddy field/wetland, upland/dry land, and open green spaces (RTH).

Land use change can be done by interpreting multi-temporal satellite imagery data from 2010 to 2018, and then calculates the extent of each land use classification. After sorting the data, we can find the area decrease or increase in the last 8 (eight) years. Digitization and interpretation are followed by field observations related to the existing land use in Pandaan District in 2018.

Whereas the identification of Urban Sprawl can be done with several calculations using data input i.e. population, built-up land, number of building units, and total land area. The areal identification of urban sprawl aims to distinguish the black and white sprawl by identifying which villages in Pandaan District are identified as urban sprawl.

This analysis also considers the ratio of households in a village/subdistrict to the total household of a village/district (A) with the ratio of the built-up land in a village/sub-district to the total built-up land in a district (B). The relationship between these two ratios are, if (A) is reduced then (B) produces a value of 0 which is considered as a normal condition, if it produces a positive value, it indicates compact and if it produces a negative value indicates sprawl [11].

The following is a table of values for Identifying Sprawl:

Table 1 Sprawl Identification

Value (A) – (B)	Comment
-	*Sprawl*
0	*Normal*
+	*Compact*

Source: Bhatta, et al. in Apriani [11]

Explanation:
(A): Ratio of households in the sub-district with the total household in the district
(B): The ratio of the built-up land in a sub-district with total built-up land in the district

3. DISCUSSION

3.1 Land use change in Pandaan District in 2010-2018

Data on land use change can be obtained from the results of digitization and interpretation of multi-temporal satellite images in the study area (Pandaan District, Pasuruan Regency, Indonesia). The following is input data in the form of satellite images of Pandaan District in 2010 and 2018. Fig. 1 is the map data from satellite imagery for land used in 2010 and Fig. 2 is land used in 2018.

The results of the interpretation of satellite imagery are classified into five types of land use, namely residential areas consisting of housing and supporting facilities, industrial areas, non-built-up lands in the form of paddy fields/wetlands, dry land, and green open spaces. Here (Fig. 3) is the results of satellite imagery interpretation and land

use tables, as well as the size area in each land use classification in Pandaan District.

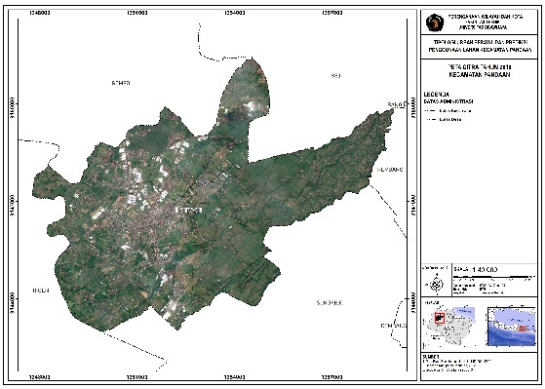

Fig. 1 Satellite Imagery in 2010

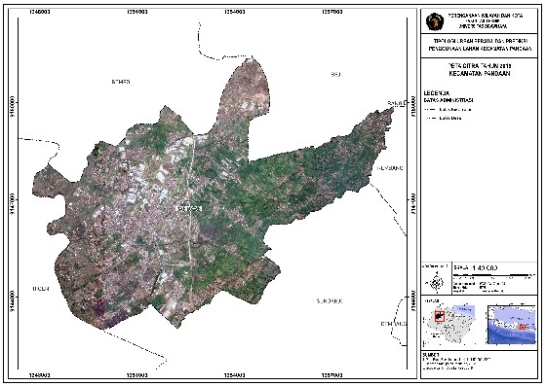

Fig. 2 Satellite Imagery in 2018

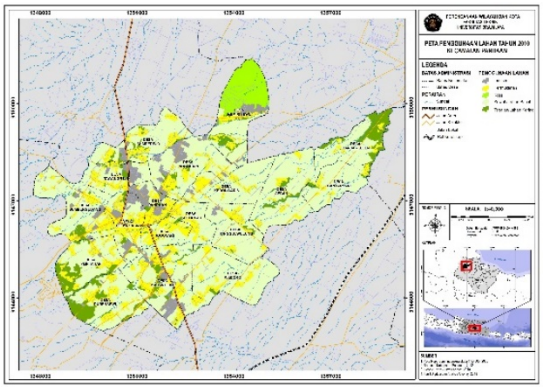

Fig. 3 Land Use Map of Pandaan District in 2010 from the interpretation result

Based on the results of satellite imagery interpretation in 2010, the results of the geometry calculation of land area in each land use classification as follows: 1) the highest use is for paddy field/wetlands (64%), followed by settlement (18,6%) drylands (7,75%) and industry 5,83% (Table 2).

Table 2 Land Use in 2010

Land use in 2010	Area (in Ha)	Percentage (%)
Industry	254.01	5.83
Settlement	810.64	18.60
Open Space	166.39	3.82
Paddy field /Wetlands	2789.21	64.00
Dry Lands	337.81	7.75
Total	4358.07	100.00

Fig. 4 is the existing land use map of image digitization results in 2018 matched with the results of field surveys related to the existing land use (Figure 3). Comparing Fig. 3 and 4, we can find the different color of settlements and paddy fields (yellow and green color).

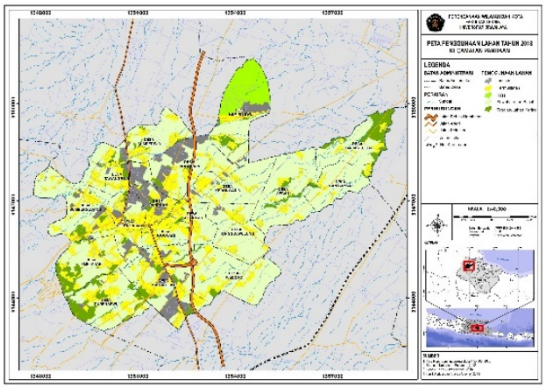

Fig. 4. Map of Land Use in Pandaan District in 2018 from the interpretation result

Based on the 2018 satellite map, image imagery analysis results, and field survey observations, the results of geometry calculations for land use in Pandaan District in 2018 are as follows: 1) the highest use is for paddy field/wetlands (59,10%), followed by settlement (21,92%), drylands (7,61%), and industry (7,57%) (Table 3).

Table 3 Land Use in 2018

Land Use in 2018	Area (Ha)	Percentage (%)
Industry	329.94	7.57
Housing	955.21	21.92
Open Space	165.96	3.81
Paddy Field/Wetlands	2575.52	59.10
Drylands	331.44	7.61
Total	4358.07	100.00

Comparing table 2 and table 3, we can see the difference. The area for settlement is increasing from 18,60% in 2010 to 21,92% in 2018. Besides the paddy field/wetlands decrease from 64% in 2010 to 59,10% in 2018. In this table, the industry

is an increase from 5,83% in 2010 to 7,57% in 2018.

The results of these interpretations are matched with the results of field observations in the form of built-up and non-built-up land use in the existing conditions. Below is the documentation of the field survey related to the land use of non-built-up lands in Pandaan District. Figure 5 and 6 show the location of the paddy field and dry land respectively.

Fig. 5 Documentation of Paddy Field /Wetlands

Fig. 6 Documentation of Drylands

Fig. 7 is the photomapping of non-built-up land use in Pandaan District in the form of paddy fields/wetlands, dry land, and open space. Our survey found that some area in 2018 change to the built-up area, meanwhile in 2010 is a un-build area in the map.

Based on the calculation of the land use area of Pandaan District in 2010 and 2018 (existing year), the area of land use pattern changes according to the classification as follows (Table 4)

Fig. 7 Photomapping of non-built-up lands land use in Pandaan District in 2018.

Based on the calculation of the land use area of Pandaan District in 2010 and 2018 (existing year), the area of land use pattern changes according to the classification as follows (Table 4).

Table 4 The extent of Land Use Changes in 2010-2018

Land Used	Area (Ha) The Year of 2010	Area (Ha) Years of 2018	Land used change (Ha)	Percentage (%)
Industry	254.01	329.94	75.93	1.742
Housing	810.64	955.21	144.56	3.317
Open Space	166.39	165.96	-0.44	-0.010
Paddy Field/Wetlands	2789.21	2575.52	-213.69	-4.903
Dry lands	337.81	331.44	-6.37	-0.146
Total	4358.07	4358.07		

The changes and development of the built-up lands are in the form of residential areas and industrial areas, which initially covered 1064.65 hectares to 1285.15 hectares, or increased by 5.059% or 220.49 hectares from the total area of Pandaan District. The increase in built-up lands led to significant land conversion, namely a decrease in the area of non-built areas in the form of rice fields/wetlands covering an area of 213.69 hectares or 4.903% of the total area of Pandaan District.

The following (Fig. 8) is a map of the development of the built-up land from 2010-2018, which is seen to be spread throughout the village or sub-district in Pandaan District.

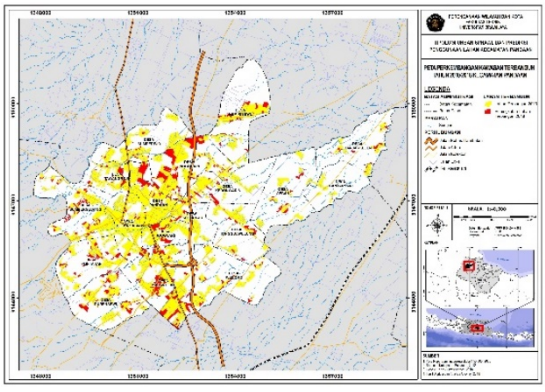

Fig. 8 Map of the development of built-up lands in Pandaan District year 2010- 201 8

3.2 Identification of Urban Sprawl in Pandaan District

Identification of Urban Sprawl is used to measure the level of sprawl based on social aspects from the population data (number of households)

and physical aspects (the built-up land). Table 5 shows the basic data used for input in identifying the level of sprawl in Pandaan District.

Table 5 Data on the head of households and built-up land in Pandaan District in 2017

No	Villages	Households	Built Up Area (Ha)
1	Plintahan	1386	90.65
2	Durensewu	1508	108.54
3	Karangjati	2658	119.8
4	Wedoro	962	81.74
5	Tunggalwulung	1033	41.51
6	Kutorejo	1509	29.02
7	Jogosari	1901	45.69
8	Pandaan	1692	69.33
9	Petungsari	1827	19.44
10	Sumbergedang	2364	96.7
11	Tawangrejo	1809	83.44
12	Sumberejo	2180	9.4
13	Nogosari	1988	131.83
14	Kemirisewu	1320	100.92
15	Kebonwaris	1174	26.9
16	Sebani	1060	35.36
17	Banjarsari	403	18.79
18	Banjarejen	725	21.58
	Total	27499	1130.64

Based on data from table 5 and the area of built-up, the highest number of households is Karangjati Village, which is 2658 households, and the lowest is in Banjarsari Village, which is 403 households. Whereas the largest land area is in Nogosari Village with an area of 131. 83 Ha, and the lowest is in Sumberejo Village which is only 9.4 Ha.

Based on the calculation results, the conditions that meet the category of sprawl are if the value (A) - (B) has a negative value (-) or less than 0. The result are: eight villages identified as having experienced Sprawl, namely: Plintah Village, Durensewu Village, Karangjatim Village Wedoro Village, Tawangrejo Village, Nogosari Village, Kemirisewu Village, and Banjarsari Village. While the results of the calculations show ten villages that have not experienced Sprawl are Tunggulwulung Village, Kutorejo Village, Jogosari Village, Pandaan Village, Petungsari Village, Sumbergedang Village, Sumberejo Village, Kebonwaris Village, Sebani Village, and Banjarkejen Village.

Table 6 Results of Urban Sprawl Identification

No	Villages	A	B	Value of Sprawl
1	Plintahan	0.0504	0.080	-0.0298
2	Durensewu	0.0548	0.096	-0.0412
3	Karangjati	0.0967	0.106	-0.0093
4	Wedoro	0.0350	0.072	-0.0373
5	Tunggalwulung	0.0375	0.037	0.0008
6	Kutorejo	0.0549	0.026	0.0292
7	Jogosari	0.0691	0.040	0.0287
8	Pandaan	0.0615	0.061	0.0002
9	Petungsari	0.0664	0.017	0.0492
10	Sumbergedang	0.0860	0.086	0.0004
11	Tawangrejo	0.0658	0.074	-0.0080
12	Sumberejo	0.0793	0.008	0.0710
13	Nogosari	0.0723	0.117	-0.0443
14	Kemirisewu	0.0480	0.089	-0.0412
15	Kebonwaris	0.0427	0.024	0.0189
16	Sebani	0.0385	0.031	0.0073
17	Banjarsari	0.0147	0.017	-0.0020
18	Banjarejen	0.0264	0.019	0.0073

Fig. 9 showing the results of the calculation of Sprawl identification based on social data on population and physical data in the form of constructed land in Pandaan District.

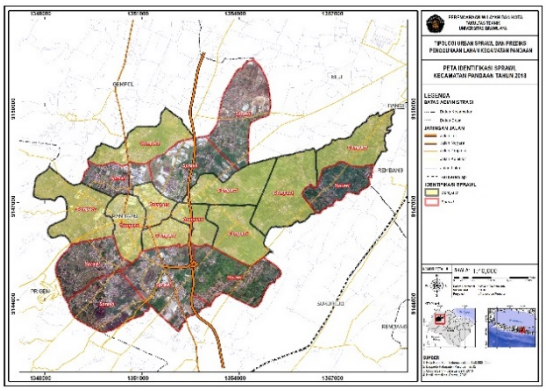

Fig. 9 Map of Sprawl Identification

4. CONCLUSION

The results of the analysis related to land use change in Pandaan District from 2010 to 2018, based on the elaboration of the results of the discussion, obtained the conclusion that the change in land use in Pandaan District in 2010-2018 had the highest change in non-built-up land use classification in the form of wetland/paddy fields. In 2010, those covered an area of 2789.21 Ha, a decrease of 213.69 Ha or -4.903% of the total area of Pandaan District initially. Non-built land change into the built-up land is in the form of industrial areas of 75.93 Ha (1.742%) and a residential area of 144.56 Ha (3.317%). Open space or (RTH/Ruang Terbuka Hijau) is in the form of field and cemeteries shrank to 165.96 Ha or a decrease of 0.44 Ha.

Based on the calculation and the identification of Urban Sprawl, the conditions that meet the category of Sprawl are if the value (A) - (B) has a

negative value (-) or less than 0. According to the results of the calculation, there are eight villages identified as having experienced Sprawl namely: Plintah Village, Durensewu Village, Karangjatim Village Wedoro Village, Tawangrejo Village, Nogosari Village, Kemirisewu Village, and Banjarsari Village. While the calculation result that shows ten villages that have not experienced Sprawl are Tunggulwulung Village, Kutorejo Village, Jogosari Village, Pandaan Village, Petungsari Village, Sumbergedang Village, Sumberejo Village, Kebonwaris Village, Sebani Village, and Banjarkejen Village.

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