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Analysis of Morphological Development Due to the Industrial Development in Majalaya District, Bandung Regency

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Abstract
Majalaya District is one of the areas close to the Upper Citarum River. Agricultural land in some areas in the district is converted for industrial development. This causes a decrease in the quantity and quality of agricultural land. The existence of land conversion can affect morphological changes. The study aims to determine the pattern of land use changes and determine the morphology of regional development in 2014 and 2021 in Majalaya District, Bandung Regency. The spatial analysis method is done by on-screen digitization, descriptive analysis and figure ground analysis. The results of this study are the pattern of land use changes using figure ground method and descriptive analysis of the morphology in Majalaya District between 2014 and 2021. Based on the results of figure ground analysis calculation on the solid classification of industrial class in 2014 it was 182,310 Ha (25%), while in 2021 it was 258,905 Ha (27.19%). Morphological analysis of the district is based on the pattern of building plots, road network patterns and building systems from 2014 to 2021. The analysis results show the district morphology of octopus/star shaped cities and unpatterned cities. This form is influenced by the development of industrial buildings in Majalaya District which causes the morphology of the area also to change.

Keywords: *Figure Ground, Industry, Land Use Change, Majalaya District, Morphology*

1. Introduction

Majalaya District is one of the area close to the Upper Citarum River. The existence of this river has an important role for the people of Bandung Regency. According to the Bandung Regency Department of Trade and Industry, the contribution of factory waste as a source of pollution to the Citarum River in Bandung Regency is around 17,957.87 kg/day (KLHK, 2017). This condition, resulted in Majalaya District being affected by pollution because that district near from the Citarum River. In addition, the existence of an industrial area in Majalaya District has also resulted of reduced green open space for groundwater absorption. This reduces the land's ability to absorb rainwater.

Majalaya District has regional limitations due to an increase in population growth from year to year and the increasing land use change. In addition, the development of industrial s in Majalaya District needs to be monitored regularly so that changes in land function can be controlled. The development of industrial also affects land conversion. This resulted in a decrease of the quantity and quality agricultural land .The existence of land conversion can have an influence on the morphology of a disctrictor city. The morphology of one city with another city can be different so that the morphology of this city becomes the shaper of the characteristics of a city. City morphology can simply be interpreted as the physical forms of the city with known structural, functional and visual. The study of city forms, morphology is usually used for the scale of cities and regions (Tallo, A J et al., 2014).

Based on the description of the problems, this study aims to determine the pattern of changes in agricultural land into industrial areas and to determine the morphology district due to the development of industrial in Majalaya District, in 2014 and 2021. The figure ground method is used to obtain the pattern of land use change, while the morphology analysis based on a descriptive analysis of the physical condition of buildings, road networks and district centers. The method of spatial analysis is also

used to observe the pattern of change by using the spatial analysis method with on-screen digitization. The land use class is based on the RTRW of Bandung Regency in 2016-2036. The on-screen digitization validation test using a confusion matrix and stratified random sampling theory with a total of 80 samples.

2. Material and Methods

2.1 Data

Data used in study which is as follows:
a. Administrative Boundary Map and Land Use Map, (BAPPEDA) Bandung Regency
b. RTRW Bandung Regency Map 2016-2036
c. World Imagery images from livingatlas ArcGIS (2014 and 2021)
d. GroundTruth Data in 2021

2.2 Morphology

Morphology city or region have three component that is ground plan (pattern road , block building), shape building (type buildings) and utilities land / building . Analysis of the shape of the city includes:
1. Compact forms consist of:
   a. The square cities
   b. The rectangular cities
   c. Fan shaped cities
   d. Rounded cities
   e. Ribbon shaped cities
   f. Octopus/star shaped cities, unpatterned cities.
2. Non-compact forms include:
   a. Fragmented cities
   b. Chained cities
   c. Split cities
   d. Stellar cities

2.2 Land Conversion

Conversion or land use change in general is the transformation of the allocation of land resources from one use to another. Agricultural land conversion is the conversion of agricultural land and all its uses to non-agricultural uses. The implication of this conversion of agricultural land to farmers is the change in the agrarian structure in the farming community. These implications can be seen after land conversion for a long period of time.

2.3 Land Use

Land use is all human intervention, either permanently or intermittently, on a group of natural resources and artificial resources, which are collectively called land, with the aim of fulfilling material or spiritual needs, or the needs of both (Kusrini et al., 2011).
1. Agriculture Land
Agricultural land has characteristics of land quality, land boundaries and land use requirements. Land agriculture have two type lands are land wet land and dry land .
2. Industrial Area
Industrial area is an area where the activities of the processing industry are concentrated, equipped with infrastructure, facilities and other supporting facilities provided and managed by an industrial company.

2.4 Land Pattern

Land use pattern is a spatial configuration or spatial arrangement in an area for a certain time. The figure ground theory is a theory that describes the total of an area. While the function of this theory is to show the texture of the area through the shape of the building mass as solid and open space as void (Tyas, W I. et al., 2014).
Textural patterns of the area can be classified into three groups, which include:
1. Homogeneous, is the arrangement of areas that are similar in nature where there is only one arrangement pattern.
2. Heterogeneous, the arrangement of areas that are several types where there are two or more patterns collide
3. Spread, the arrangement of areas that are spread and tend to be chaotic.

2.5 Geographic Information System

Geographic Information System (GIS) is a computer-based information system for storing, managing and analyzing, as well as processing georeferenced data (Wibowo, K. M. W et al., 2016). Geographic Information System (GIS) is a unity between several physical and logical elements that is related to the spatial phenomenon of the objects on the surface of the earth (Prahasta, 2015).
1. Generally, digitization is an activity in changing geographical features on raster data into a digital format with a vector format by using a digitizer connected to the computer (ESRI, 2004 in Fadila R., 2018).
2. Topology rules function to produce correct data according to GIS concepts, ArcGIS software provides filtering facilities to automatically check (query) errors and perform spatial and attribute editing (validation). Topology is defined by the user according to the characteristics of the data such as lines, polygons, or points. Each characteristic has a certain rule (Ostip, 2011). Topology is also used to ensure that the data produced is properly geometric.

2.6 Validation Test

Validation test is the accuracy of an instrument in measurement. In testing the data collection instrument, the validity are divided into factor validity and item validity (Dewi, 2018).
1. Planimetric test is carried out to compare the distance between objects in the field with the corrected satellite image interpretation results. The results of the comparison of the distance calculation in the field with the distance in the satellite image are then calculated with the RMSE value. The formula in calculating the RMSE value of the distance is:

$$RMSE = \frac{\sqrt{\Sigma(\Delta_D - \text{mean of } \Delta_D)^2}}{\text{n}} \quad (1)$$

Where :

Δ_D = The difference between the distance in the field and in the image

n = Total sample

The results of the distance RMSE must meet the distance planimetric error tolerance based on the Regulation of the State Minister of Agrarian / Head of the National Land Agency Number 3 of 1997 about Technical Guidelines for the Registration Base Map, is :

$$RMSE \leq 0{,}3\ mm \times \text{map scale} \quad (2)$$

2. The confusion matrix is a matrix that indicates the level of accuracy of the image that has been classified to the reference data. The accuracy of the classification results is tested by making a contingency matrix which is often called an error matrix or confusion matrix (Asma, N, 2018). The matrix calculated in the confusion matrix is the producer's accuracy, user's accuracy, overall accuracy and kappa accuracy.

Table 1. Form of Confusion Matrix

Reference Class		Interpretation Data			Amount of Sample	*User Accuracy*
		A	B	C		
Data Reference	A	X_{11}	X_{12}	X_{13}	X_1+	$X_{11}X_1+$
	B	X_{21}	X_{22}	X_{23}	X_2+	$X_{21}X_2+$
	C	X_{31}	X_{32}	X_{33}	X_3+	$X_{31}X_3+$
Total Sample		X_1+	X_2+	X_3+	N	
Producer's Accuracy		$X_{11}X_1+$	$X_{21}X_2+$	$X_{31}X_3+$		Xii

$$\text{User's Accuracy} = \frac{X_{11}}{X_{1+}} X\ 100\% \quad (3)$$

$$\text{Producer's Accuracy} = \frac{X_{1+}}{X_{11}} X\ 100 \quad (4)$$

$$\text{Overall Accuracy} = \frac{(\Sigma\, X_{ii}\, r\ i=1\ )}{N} X\ 100\%) \quad (5)$$

$$\text{Kappa Accuracy} = \frac{N\ \Sigma\, X_{ii}\ r\ i=1 - \Sigma\, x_{i+}x_{+i}\ r\ i=1}{N2-\Sigma\, x_{i+}x_{+i}\ r\ i=1} X\ 100\% \quad (6)$$

Formula Information :

N = Number of sample

Xi+ = Sum of sample in line i

X+i = Sum of sample in column i

Xii = The diagonal values of the i row and i column contingency matrices

3. Stratified Random Sampling

This sampling method is used in populations that have a stratified or multi-layered arrangement. This technique is used when the population has members/elements that are not homogeneous and stratified proportionally so that each stratum must be represented in the sample.

2.7 Method of Research

The method of reasearch in this study consists of 4 stages i.e. preparation, data acquisition, data processing and analysis. The preparation stage contains the identification of problems that occur in Majalaya District based on literature studies and paper reviews. Literature study is done by looking for scientific references related to the research. Data collection and preliminary survey were conducted to collect primary and secondary data. The data processing stage begins with cropping the 2014-2021 image with the administrative boundaries of Majalaya District. Furthermore, on-screen digitization is carried out using a fixed scale at the time of digitizing, which is a scale of 1:5,000. After digitizing, then the topology process to eliminate errors during digitization.

After digitizing and topology, for the figure ground analysis, it is necessary to classify the solid part (the mass of the building) and classify the void elements of open space in the building (all the space outside that mob/farmland). After analyzing the results of the figure ground analysis, it is necessary to do a morphological analysis of Majalaya District in 2014-2021. In this analysis, a descriptive analysis is carried out which analyzes the pattern of building plots, road network patterns and the center of the district.

Then the next step in the digitization process is to check the digitization results with the actual conditions in the field. This check is done through the process of testing the accuracy of the digitization process results using a confusion matrix table. This table is used to provide information on the relationship of each land use classification with samples taken in the field. The area calculation aims to provide information about the area of each land use classification in Majalaya District. Spatial analysis method with overlay is carried out to determine changes in land use which will later to be used as study material to determine and analyze the suitability of land use changes and morphological analysis in Majalaya District.

3. Results and Discussion

3.1 The Pattern of Changes in Agricultural Land to Industrial

Figure Ground analysis was conducted to identify the pattern of physical changes in the industrial area of Majalaya District in 2014-2021. The ground figure analysis uses two elements, i.e. solid and void elements, the figure symbolizes the built mass (solid shown in black) and for all spaces outside the built mass (void shown in white). Based on the figure ground, the texture patterns of Majalaya District in 2014-2021 can reveal the pattern of development and physical changes in the industrial area in Majalaya District seen from the texture pattern of the area.

3.1.1 Figure Ground in 2014

Based on the figure ground analysis, it can be concluded that most of the spatial patterns that occurred in Majalaya District in 2014 were heterogeneous regional patterns. A collection of building masses that have various types of shapes and distances. Solid elements in the form of blocks that define the side of the road because the mass of

buildings accumulate on the side of the road, and continues to cluster on the right and left sides of the road. In this analysis, only solid elements are used in the industrial area, which can be seen in **Figure 1.** The solid classification area for land use in 2014, industrial has an area of 182,310 Ha or 25%.

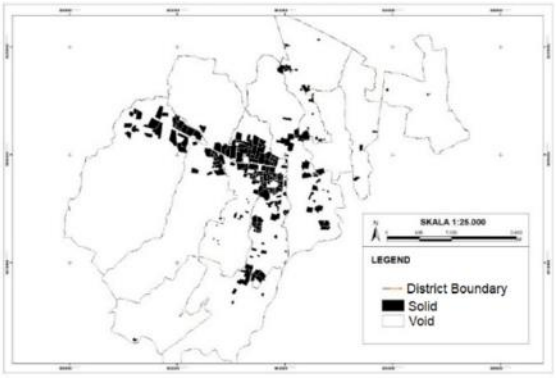

Fig 1. Figure Ground Map in 2014

3.1.2 Figure Ground in 2021

The pattern in 2021 is the same as in 2014 with a heterogeneous pattern. Based on the figure ground analysis of the distribution of solid and void classifications in Majalaya District, it can be seen in Figure 2. The area of solid classification in 2021 for industrial has an area of 258.905 Ha or 27.19%.

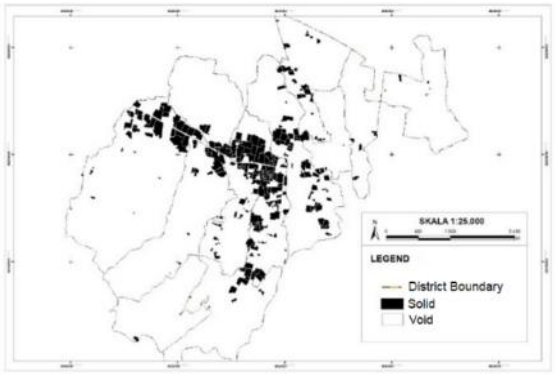

Fig 2. Figure Ground Map in 2021

3.1.3 Change of Agricultural Land to Industrial

Based on Table 2, it can be seen that Mixed Gardens in 2014 changed in 2021 to an industry covering an area of 8,308 Ha or 18.566% ; Dry Fields in 2014 turned into an industry covering an area of 0.155 Ha or 0.346% ; Vacant Land in 2014 to an industry covering an area of 2,736 Ha or 6.114%. Irrigated rice fields in 2014 turned into an industry covering an area of 32.599 ha or 72.849% ; rainfed rice fields in 2014 turned into an industry covering an area of 0.929 ha or 2.076% ; shrubs in 2014 turned into an industry covering an area of 0.022 ha or 0.049%.

It can be concluded that for the classification of voids (all space outside the building mass) in 2014 and 2021 its area is reduced. The decrease in agricultural land based on the analysis of patterns and calculations above shows that industry buildings are a factor in changing agriculture land in Majalaya District.

Table 2. Change of Agriculture Land to Industrial in 2014-2021

No	Agriculture Land in 2014	Land Use in 2021	Area Ha 2014-2021	Percentage	Information
1.	Mixed Gardens	Industry	8.308	18.566%	Changed
2.	Dry Fields	Industry	0.155	0.346 %	Changed
3.	Vacant Land	Industry	2.736	6.114%	Changed
4.	Irrigated rice fields	Industry	32.599	72.849%	Changed
5.	Rainfed rice fields	Industry	0.929	2.076%	Changed
6.	Shrubs	Industry	0.022	0.049 %	Changed
	Total		**44.749**		

3.2 The Morphology of Majalaya District, Bandung Regency

Analysis of the morphological development was carried out by descriptive analysis with the parameters of the building plot pattern, the pattern of the road network and the center of Majalaya District in 2014 and 2021.

3.2.1 The Building Plot Pattern

The pattern of building plots in Majalaya District has changed in terms of size (dimensions) so that it can affect land use changes. The plot pattern only analyzes in industrial areas, where it can be seen the changes in industrial buildings and how many industrial buildings in Majalaya District in 2014. The building plot pattern is dominated by industrial buildings with the total number are 112 industries in 2014.

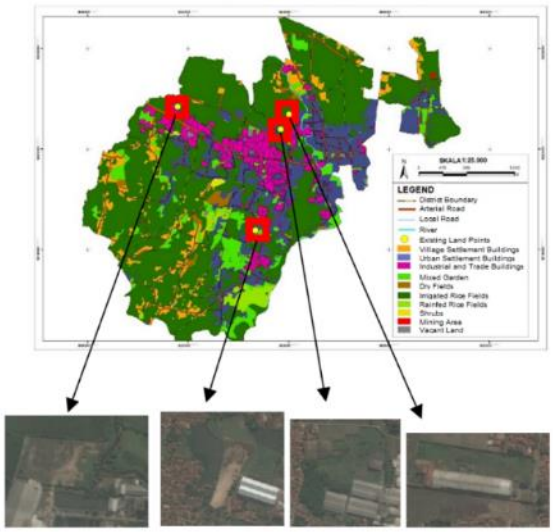

Fig 3. The Building Plot Pattern in 2014

Based on Figure 3, the existing condition shown in 2014 is the use of irrigated rice fields, which in 2021 will turn into Industrial Buildings. Based on Figure 4 shows the change in the use of irrigated rice fields into Industrial Buildings, Village Settlement Buildings, Urban Settlement Buildings and Trade Area. Based on the results of the analysis of land use changes into industrial buildings, it changed by 42,013 Ha. Overall, the distribution pattern of building plots in Majalaya District is on the primary arterial road network and the local road network. There were 112 industrial buildings in 2014 and an increase in 2021 to 146. It can be concluded from the results of the analysis that the use of agricultural land continues to decrease due to the increase in industrial buildings.

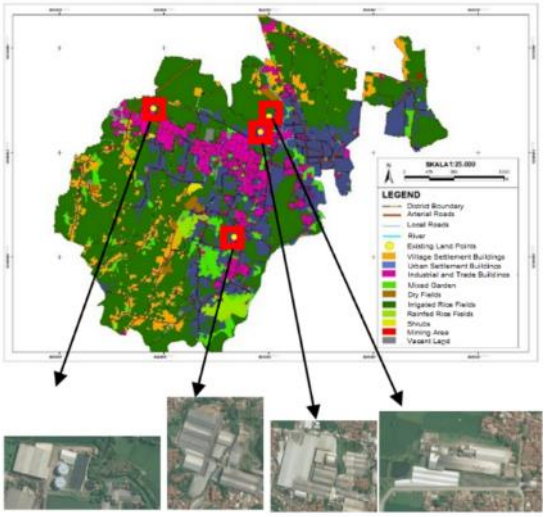

Fig 4. Change of Irrigated Rice Fields to Industrial Buildings in 2021

3.2.2 The Pattern Of The Road Network

The pattern of the road network in Majalaya District has changed, from the basic shape of the main road and the width dimensions. Majalaya District has a radial road pattern. The radial pattern is identified from the primary arterial road in the residential area as the main road. Based on the service function, the road network of the Majalaya District consists of a primary system which is the link between primary functions in the Majalaya District while the local road network/environmental road is located in a residential area. The primary arterial road network functions as a connecting road between regional centers such as settlements and trade. The road network pattern of the Majalaya District in 2014 can be seen in Figure 5.

Based on Figure 5 and Figure 6 the condition of the road network in 2014-2021 has changed where in 2014 the condition of land use was Irrigated Rice Field and changed to arterial roads and local roads. Changes in the pattern of the road network follow the development of the resident activities in Majalaya District. The development of trade and residential buildings will lead to the development of new primary arterial roads and local roads. The road is used by residents as a connecting road from one place to another. It can be concluded that the addition of new roads in Majalaya District is also dominated by the development of industrial buildings which affect the morphology in the around industrial buildings. With the addition of new buildings, the road network in the industrial building area will also develop, besides that, residential areas and public facilities will also increase.

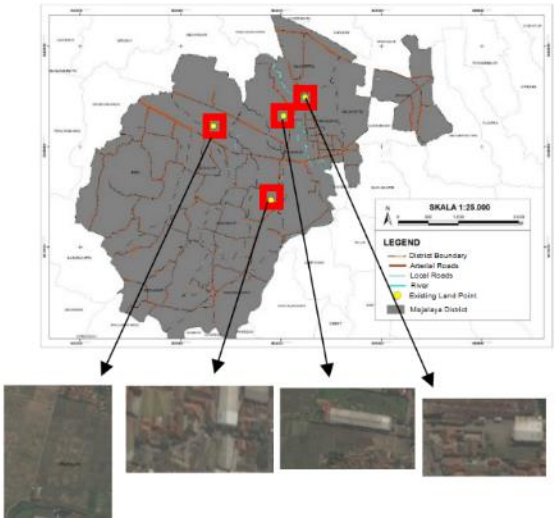

Fig 5. Existing Industrial Area In 2014

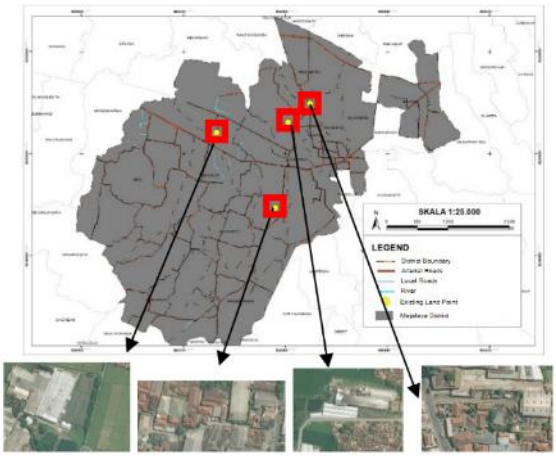

Fig 6. Irrigated Rice Fields to Road Network in 2021

Based on Table 3, the total area of the road network pattern changes is 48,745 m^2. The highest change in road network pattern occurred in the use of irrigated rice fields which became arterial roads covering an area of 42,806 m with a percentage of 87.817%. The new road network is located in the industrial area and its distribution center is on the primary arterial road network around the industrial area, while local roads to reach village settlements are still limited. In general, it can be concluded that the development of arterial roads and local roads in 2014-2021 changed to more with the change in the function of irrigated agricultural land for the construction of new arterial roads and local roads.

Table 3 Irrigation rice fields to Arterial and Local Roads in Majalaya District

No	Land Use 2014	Land Use 2021	Area (m)	Percentage	Information
1.	Irrigation rice fields	Arterial Road	42,806	87.817 %	Changed
2.	Irrigation rice fields	Local Street	5,939	12.183 %	Changed
	Total		**48,745**		

3.2.3 The Center Of Majalaya District

The Regional Center in Majalaya District is along in Jalan Raya Laswi, where on Jalan Raya Laswi the concentration of activity in the area is marked by trade and service activities.The morphology of the Majalaya District in 2014 and 2021 can be seen in Figures 7 and 8. Land use around Jalan Raya Laswi is dominated by industrial buildings. The industrial building has a total area (109,580 Ha) or 71.82% of the total land use around Jalan Raya Laswi.

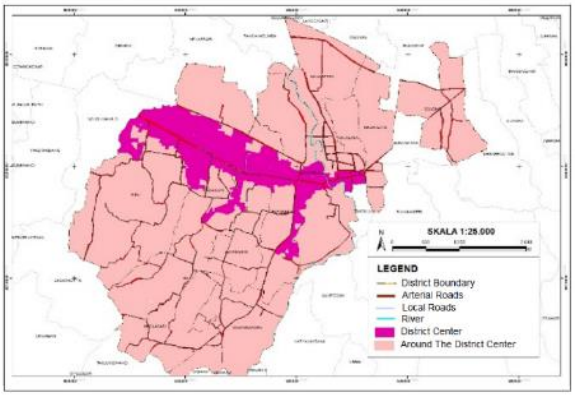

Fig 7. Morphology Forms in Majalaya District in 2014

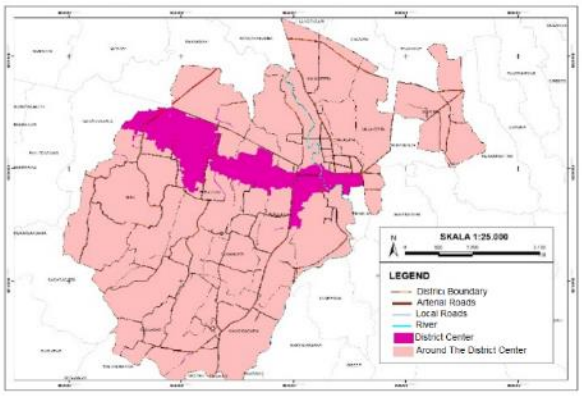

Fig 7. Morphology Forms in Majalaya District in 2021

The results of the combination of three morphology parameters, i.e the pattern of building plots, the pattern of the road network and the center of the district, show the morphology is octopus/star shapedcities and unpatterned cities. The morphology of Majalaya District consists of three parts :

1. The core is the center of the area which indicates the concentration of activities that have an impact on building density. Activities in the center of the Majalaya District area are characterized by trading, service and industrial activities.
2. The framework part is the basic structure of the morphological appearance of Majalaya District with the framework formed by the road network pattern, where the road network pattern in Majalaya District is a radial pattern.
3. The body part is the development of the skeletal part. The body part is usually identical to the built-up land that develops around the center of the area, then follows the road pattern.

In this morphology form, there are several prominent transportation routes and also inland/rural areas. Generally, Majalaya District has an octopus or star morphology which is influenced by the growth or development of industrial buildings in Majalaya District which causes the morphology of the area around to the industry also change. The development of industrial areas affects the development of infrastructure, settlements, as well as primary arterial roads and local roads in the industrial area.

4. Conclusions

Based on the results of the study, it can be concluded that the figure ground analysis conducted in 2014-2021 the resulting pattern is a heterogeneous pattern. Solid classification in industrial class in 2014 was 182,310 Ha or 25%, in 2021 it will increase to 258,905 Ha or 27.19%. Void classification (all space outside the mass/agricultural land) in 2014-2021 land area is reduced. The decrease in agriculture land shows that industrial buildings are the cause of changes in agricultural land in Majalaya District. The results of the combination three morphology components shown morphological forms octopus/star shapedcities and unpatterned cities. In this form there are several prominent transportation routes, there are also some inland/rural areas, besides that on the diistrict side there is no physical development.

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