CHAPTER I
INTRODUCTION

1.1. Introduction

Central Java Province has manufacturing industry as the base sector with a contribution to GRDP of 34.42% (Central Bureau of Statistics, 2019). The contribution of the industrial sector is mainly supported by the growth of the industrial estates located on the northern coast of Central Java Province (Kendal-Semarang-Demak). This is in accordance with research conducted by Zhang et al. (2019) that the high contribution of the industrial sector to the GRDP has a positive effect on the growth of industrial estate. The Semarang Metropolitan Coast having a role as the Center for Industrial Growth (WPPI) in Central Java Province based on the 2015-2035 National Industrial Development Master Plan (RIPIN). The high industrial growth in the northern coast of Central Java is supported by the infrastructure such as National Road Route 1 (North Coast Road), Trans Java Highway, Tanjung Mas Port and Ahmad Yani International Airport which supports industrial export and import activities.

Coastal areas often experience the high industrial growth due to various supporting aspects such as topography, access to infrastructure, high market demand and ease of disposal of waste to the sea (Hong, 1991). Industrial growth in Semarang Metropolitan Coast has an impact on the conversion of coastal ecosystem to built up area. Based on previous research, industrial growth in Semarang Metropolitan Region, especially in the north, east and south, has a significant impact on land use changes and increaseing the built up area (Sejati et al., 2019). In addition, most studies on industrial land efficiency only focus on the land use patterns of economic activity, not on the development of the area of industrial land used (Desouza & Malhi, 2017). Based on these phenomena and problems, this research needs to be done to determine the direction and trends of industrial growth as an evaluation during the implementation of industrialization policies that started in 2015 and whether the industrial zones in the spatial plan has accommodated the industrial growth based on the results of industrial growth predictions in 2030. This evaluation is important to be done based on Government Regulation of the Republic of Indonesia Number 142 of 2015 that every industry must be located at industrial zones in accordance with the regional spatial plan.

This research is also needed because the more precise estimation of industrial growth has not been accommodated in various previous studies (Qiu et al., 2015) then it needs to be supported by a new method of Geographic Object-Based Image Analysis (GeOBIA) combined with manual interpretation to estimate the growth of industrial-built up area and the growth prediction in 2030 using CA-Markov. The GeOBIA method is superior for use in spatial planning because land cover classification is done by considering spatial aspects, not just spectral aspect so the classification result is more detailed than pixel based classification *(*Blaschke et al*.*, 2014). This is in accordance with the research conducted by Im et al. (2008) that the Geographic Object Based Image Analysis (GeOBIA) has a higher kappa index than the results of detection using other methods. Measurement of the temporal spatial pattern of urban growth is important for a better understanding the effects of spatial distribution both qualitatively and quantitatively. Understanding of land use changes is needed to determine the potential for future development and avoid the negative impacts that may occur (Alqurashi & Kumar, 2016).

1.2. Research Objectives and Targets

This study aims to identify the direction and trends of industrial growth in 2015-2020 based on the Geographic Object-Based Image Analysis (GeOBIA) combines with manual interpretation and predictions of industrial growth in 2030 using CA-Markov to assess the industrial zones in spatial plan. The results of this study are expected to be a reference for further research in the area of urban and regional planning related to the assessment of industrial zones in spatial plans based on the prediction of the direction and trends of industrial growth. The research objectives will be achieved through the following target stages :

a. Identify the characteristics of the study area and the existing industrial location;
b. Modeling industrial growth using Sentinel-2A Satellite Imagery in 2015 and 2020 and predicting the industrial growth in 2030;
c. Analyze the direction and trends of industrial growth;
d. Validate and display the accuracy of the modeling results; and
e. Evaluate the industrial zones in regional spatial plan based on the results of industrial growth model.

1.3. The Research Scope

The research scope includes the scope of study area and the scope of the substance. The study area is Semarang Metropolitan Coast which is the location of observation. The scope of the substance includes the aspects that will be analyzed in this study.

1.3.1. The Study Area Scope

The scope of the area included in this study is the villages/ sub-districts in the coastal area bordering or located close with the Java Sea, the North Coast Road and the Trans Java Highway, and included in the administrative areas of Kendal Regency, Semarang City, and Demak Regency (Semarang Metropolitan Coast). The total area of observation is 37,793.48 hectares (or 377.93 km^2). The administrative area includes 4 districts in Kendal Regency, 10 districts in Semarang City, and 4 districts in Demak Regency.

1.3.2. Substantial Scope

The scope of the substance in this study includes the evaluation of industrial zones in regional spatial plan based on industrial growth models in 2015-2020 and industrial growth prediction in 2030 using CA-Markov. The results of this modeling are used as an evaluation during the process of industrialization policy implementation that started in 2015 and assessing the industrial zones in the regional spatial plan based on the industrial growth prediction model in 2030. This assessment is needed to be an evaluation for controlling the spatial use in Semarang Metropolitan Coast.

1.4. Research Benefit

This research is expected to be useful in the long term for various parties related with the industrial growth on Semarang Metropolitan Coast such as academics, industrial enterprises and the Regional Government of Kendal Regency, Semarang City, Demak Regency, and the Regional Government of Central Java Province. The existence of this research is expected to be one of the supporting references for various further studies, related to the modeling of industrial growth predictions. As for the regional government, it is hoped that this research can be used to evaluate industrial zones in the 2011-2031 spatial plan based on the direction and trends of industrial growth in 2015-2020 and the growth prediction in 2030.

1.5. Research Method

This study aims to determine the industrial growth in the Semarang Metropolitan Coast for asessing the industrial zones in spatial plan. The method used in this study is a quantitative method through satellite imagery classification using combination of GeOBIA (Geographic Object-Based Image Analysis) method with manual interpretation and prediction of industrial growth in 2030 using CA-Markov.

1.5.1 Image Classification using GeOBIA and Manual Interpretation

GeOBIA starts with image segmentation by grouping pixels into objects. The GeOBIA method, considers spectral, texture, context, and shape with an algorithm for groups of pixels (Addink et al., 2012). The GeOBIA method consists of 2 main processes namely the object segmentation process and the object classification process.

a. Object Segmentation

The first step in GeOBIA is to choose the appropriate segmentation. There are various segmentation algorithms available, most using certain parameters to produce shapes and sizes of objects (Bialas et al., 2019). When there are many methods that measure the quality of segmentation (Clinton et al., 2010), or producing the supervised or unsupervised segmentation, there are still many who consider measurement with the best segmentation quality as a result of classification (Liu & Xia, 2010). The method in determining segmentation parameters generally consists of two categories, namely supervised and unsupervised. The supervised method takes training sample data, usually in the form of polygon delineation on existing objects and measures the quality of segmentation to define optimal segmentation (Li et al., 2012). The unsupervised method does not depend on training sample data, and looks at diversity in intersegments (Drăguţ et al., 2010).

In this study, image segmentation is done through the Orfeo Toolbox Plugin using Sentinel-2A imagery with multi-index composite bands NDTI, NDVIre and MNDWI with a resolution of 20 m to obtain more accurate segmentation results in distinguishing identification of agricultural land cover and vacant land with built-up land and industry compared using natural band composites (Osgouei et al., 2019). Orfeo Toolbox is an open-source plugin that is used to process high-resolution and multispectral images. The image segmentation process uses the LargeScaleMeanShift tool on the Orfeo Toolbox Plugin with a spatial radius of 1, a radius range of 0.001, and a minimum segment size of 10. The mathematical logic used in the segmentation process is (Wang et al., 2004) :

$$f = \sum_{i=1}^{i=n} Wi\left(n_{Merge}\sigma_{Merge} - (n_{Obj1}\sigma_{Obj1} + n_{Obj2}\sigma_{Obj2})\right)$$

Description :

n : number of bands

Wi : band weights

$nMerge$, $nObj1$, $nObj2$: number of pixels in an object, initial object 1, initial object 2

$\sigma Merge$, $\sigma Obj1$, $\sigma Obj2$: variance on object, initial object 1, and initial object 2

f : level of pixel heterogeneity in objects

The results of objects that have been formed from the image segmentation process are used in the image object classification stage.

b. Object Classification

After the object is formed from the image segmentation process, then the object classification process is needed to be certain classes. In this study there are 5 classes of objects namely the water body, vegetation, agricultural land and vacant land, built up area, and industry. Industrial class types are distinguished from built up area through the rooftop contained in industrial buildings and non-industrial built land. Most of the building rooftop in industry are made of aluminum and concentrated materials, while other (non-industrial) building rooftop are made of materials other than aluminum (Osgouei et al., 2019). Classification can be done on a sample (sample-based) or rule-based basis. This study uses a classification based on sampling (sample-based). The image object classification process begins with the stage of taking the training set. This training set is made by taking a minimum sample of 150 samples in each class of objects from the results of segmentation. After the training set has been made, the next stage uses the Vector Classifier tool.

There are industrial classes that classified as non-industrial built up area based on the results using the GeOBIA Method because similar rooftop mainly in commercial buildings. This study adopts a combined GeOBIA method and manual interpretation to obtain the classification result more closely with the existing conditions. Manual interpretation uses the results of segmentation and classification produced by the GeOBIA Method, then editing the attribute tables on thematic vector data based on the overlay between the GeOBIA classification results and high resolution satellite imagery. This method is able to improve accuracy in the industrial class, but the weakness of the method used in this study is the limited human ability to interpret at the large scope of the Semarang Metropolitan Coast so it requires high effort and time. As compared with the previous method of image interpretation using manual delineation which requires more time, this method is much more efficient and requires shorter time because it uses the results of segmentation and classification result based on GeOBIA and only uses the manual interpretation for edit the attribute table to obtain the classification results more closely with the existing conditions. Pixel-based classification also difficult to distinguish between industrial buildings and non-industrial buildings due to similar types of rooftop and the thematic data attributes on raster-based data result cannot be modify as can be done on vector data generated by the GeOBIA method. The synergistic combination between manual interpretation and automatic classification based on GeOBIA is more effective to reduce the misclassifications of objects with similar features (Souza-Filho et al., 2018).

1.5.2 Industrial Growth Prediction using CA-Markov

The CA-Markov model is used in this study to predict the extent and distribution of industrial growth in Semarang Metropolitan Coast in 2030 based on the results of 2015 and 2020 Sentinel-2A image classification. The CA-Markov model is a process that analyzes the possibility of changes in land cover and land use conditions at a location at time t_2 predicted based on conditions at time t_1 (Houet & Hubert-moy, 2006). This method is widely used to identify changes in land cover and land use, forest land cover, urban sprawl, wetland landscape, vegetation growth, optimum location selection, coastal zone management and others (Ghosh et al., 2017). Prediction of future conditions using the CA-Markov Model is generally done through analysis of land cover classification and land use at different times (Moghadam & Helbich, 2013). The transition likelihood matrix shows the likelihood of changing one condition at a time into another in the future (Moghadam & Helbich, 2013). In image analysis using remote sensing data, changes in pixel values indicate changes in land cover. Changes can be seen from the value of pixels that are converted into units of area, the area of change in land cover can be calculated, besides the transition matrix becomes the basis of the Cellular Automata Model (Guan et al., 2011). In the CA-Markov model, changes in land cover are part of a stochastic process. The condition at time t depends exclusively on the time condition t-1. Calculation of transition possibilities is written as follows (Ghosh et al., 2017) :

$$P\{X_t = a_i \mid X_0 = a_0, X_1 = a_1,...,X_{t-1} = a_i\} = P\{X_t = a_i \mid X_{t-1} = a_i\}$$

With the process of change happening on time (t = 0, 1, 2, ...)

In the calculation above, $P\{X_t = a_j \mid X_{t-1} = a_i\}$, is a possible transition from the condition of a_i to a_j at one stage of time. If stage 1 can be implemented in this transition, it is referred to as stage 1 possibilities, shortened to $P_{ij}^{(l)}$. *CA-Markov becomes homogeneous when* $P_{ij}(l)$ depends on the conditions of a_i, a_j and l.

Based on the calculations $P\{X_t = a_i \mid X_{t-1} = a_i\}$ sebagai P_{ij}, then obtained :

$$P\{X_t = a_i \mid X_{t-1} = a_i\} = P_{ij}$$

The condition is obtained from observing data through the calculation of the total time the condition changes from i to j (n_{ij}) and the number of occurrences of a_j. For the transition matrix, each element contains an observation category and the number of transition expectations as contained in the following calculation,

$$\mathrm{X} = \Sigma \frac{(O - E)^2}{E},$$

Where O is the number of observations of the transition and E is the expected number of transitions. In each case, the conditions of success can be different.

The CA-Markov model is found in the MOLUSCE (open source) plugin in the QGIS 2.8 application used in this study. The MOLUSCE plugin is used to analyze changes in land use and vegetation cover and to simulate land use/ land cover predictions. The MOLUSCE plugin takes into account changes in land use/ land cover effectively. MOLUSCE plugin consists of 7 main stages :

1. Input

   This component serves to include the results of land cover classification (in the form of raster) in the initial year (2015) and the final year (2020) along with the spatial variables that influence. In this component there is also a "check geometry" function to ensure all data sets have the same spatial geometry (such as spatial resolution).

2. Evaluation Correlation

   This study uses the Pearson's Correlation Method in testing the relationship between spatial variables that will be used to predict the industrial growth. Pearson's Correlation is a statistical test that measures the statistical relationship, or association between two variables. The interrelationships between variables based on Pearson's Correlation Coefficient are shown in the table 1.1.

Table 1. 1 The correlation level between variables based on Pearson's Correlation Coefficient

Coefficient Value	**Correlacy**
0	*No Corellation*
< ± 0.30	*Fair*
± 0.30 – ± 0.49	*Moderate*
± 0.50 – ± 0.99	*High*
± 1.00	*Perfect*

3. Area Change

   In this component, changes and probability of land use / land cover transition are taken into account. The area of land use / land cover can be displayed in units of square meters, square kilometers and hectares.

4. Transition Potential Modelling

   This study uses the Artificial Neural Networks (ANN) method at the Transition Potential Modeling stage. This method uses information on land use/ land cover changes and spatial variables as input to calibrate and create predictive models of land use/ land cover changes.

5. Cellular Automata Simulation

   Simulation prediction of land use / land cover change is formed on this component. The Cellular Automata approach is based on the Monte Carlo Algorithm.

6. Validation

   The validation component takes into account kappa statistics (kappa standard, kappa histogram and kappa location). Kappa statistics shows the percentage of accuracy between the two maps, including the quantity and location of information (Hagen, 2002). The kappa statistics formula is illustrated as follows :

   $$\text{Kappa} = (P0 - Pe)/(1 - Pe)$$

   Where P_0 is the estimated accuracy of observation and Pe is the expectation of observation accuracy. The Kappa Index is divided into 5 categories with more information in the table 1.2.

Table 1. 2 Kappa Index Category

K	**Similarity**
< 0.2	*Poor*
0.21 – 0.4	*Fair*
0.41 – 0.6	*Moderate*
0.61 – 0.8	*Good*
0.81 – 1.00	*Very Good*

Sumber : (Jenness & Wynne, 2007)

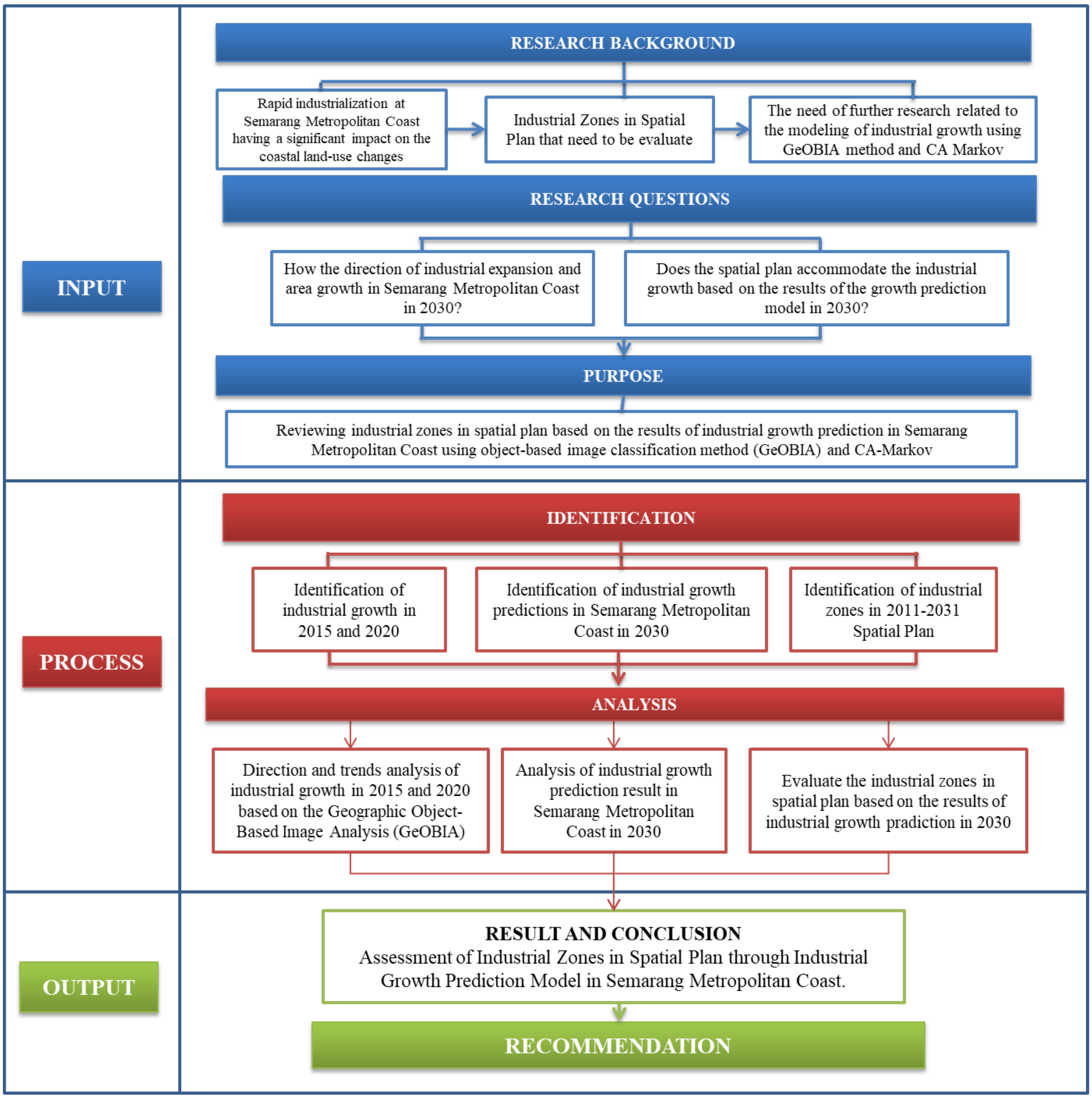
7. *Messages*

   This component displays the progress of the modeling or simulation as well as a notification if there is an error in the modeling.

1.6. Logical Framework

This research is conducted based on the rapid industrial growth in the Semarang Metropolitan Coast. Industrial growth was supported by the implementation of the National Industrial Policy in 2015, through the establishment of industrial zones in spatial plan to allocate the industrial growth and minimize unplanned industrial growth. Evaluation is needed to determine whether the industrial zones in spatial plan has accommodated the industrial growth in the Semarang Metropolitan Coast. In addition, there has been no research related to modeling industrial growth predictions using the GeOBIA and CA-Markov methods. After the process of identification and analysis is carried out, an assessment of the industrial zones is produced based on the industrial growth model in 2015-2020 and the predictions of industrial growth in 2030. The research framework is shown in the figure 1.1.

Figure 1. 1 Logical Framework



Source : Author's Analysis, 2020

1.7. Data Collection and Analysis Methods

This section contains data collection techniques, research data, analysis techniques, and sampling techniques. Data collection techniques and details of data requirements related to secondary data in the form of satellite imagery. While the technical analysis section contains the stages of land cover classification using the GeOBIA Method and prediction industrial growth using the CA-Markov Model.

1.7.1 Data Collection Techniques

The secondary data used in this study is the Sentinel-2A image. Sentinel-2A image data is obtained free of through the USGS (United States Geological Survey) page. The primary data collected in this study are coordinated photographs during the field observation. The observation activity in this study aims to observe the existing land use conditions on the Semarang Metropolitan Coast. The results of the field observations will be used to validate the GeOBIA classification result and validate the prediction model.

1.7.2. Research Data

This study uses secondary data in the form of Sentinel-2A Imagery in 2015 and 2020. The research years used are 2015 and 2020 because there is a 2015-2019 National Industrial Policy that supports industrial growth through the development of industrial zones. Primary data (in the form of coordinated photographs) in this study were used to validate the results of the classification result and validate the industrial growth prediction models. The results of the classification of objects using images in that year are used as a reference for spatio-temporal changes within a period of 5 years. Secondary and primary data used in this study are included in table 1.3. The image classification uses a multi-index composite NDTI band (classification of built land), NDVIre (vegetation classification) and MNDWI (classification of water bodies) with a spatial resolution of 20 m as in Figure 1.2. This is done because the multi-index composite band (NDTI, NDVI, MNDWI) with a spatial resolution of 20 m has a much higher level of accuracy compared to using a natural band composite (B4, B3, B2) with a spatial resolution of 10 m which has a weakness in distinguishing type of land cover class built with agricultural land and vacant land (Osgouei et al., 2019). Composite multi-index bands of NDTI, NDVIre and NDWI as well as the spatial resolution of each band are described in table 1.4 and table 1.5.

Figure 1. 2 Sentinel-2A Band Composite

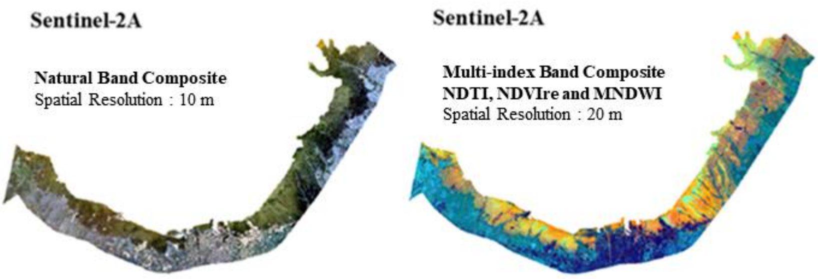


Table 1. 3 Primary and Secondary Data

Objectives	Data	Year	Data Type	Data Form	Collection Techniques	Sources
Identify the characteristics of the study area and the existing industry	Gross Regional Domestic Product (GRDP)	2015, 2020	Secondary	Document	Data Download	Central Bureau of Statistics
	List of Industrial Estates in Semarang Metropolitan Coast	2020	Secondary	Document	Data Download	Ministry of Industry, Regional Regulation of Central Java Province 2017-2037
Modeling industrial growth using Sentinel-2A Imagery in 2015 and 2020 and predicted growth in 2030	*Sentinel-2A Tile Number T49MDN*	2015	Secondary	Satellite Imagery	Data Download	*USGS*
		2020	Secondary	Satellite Imagery	Data Download	*USGS*
	Road Network	2015, 2020	Secondary	Document	Data Download	Geospatial Information Agency
	Land Price	2020	Secondary	Map	Data Download	Ministry of Agrarian Affairs and Spatial Planning
Field Observation	Existing Condition	2020	Primary	Photograph	Observation	Field Observation
Evaluate the Industrial Zones in the 2011-2031 spatial plan based on the results of industrial growth model	Regional Spatial Plan of Kendal Regency, Semarang City and Demak Regency	2011-2031	Secondary	Document	Data Download	Development Planning Agency of Kendal Regency, Semarang City and Demak Regency; GISTARU Ministry of Agrarian Affairs and Spatial Planning

Source : Author's Analysis, 2020.

Table 1. 4 Multi-Index Band Composites (NDTI+NDVIre+MNDWI)

Index	ID Index	Band	Formula	Application
Modified Normalized Difference Water Index	MNDWI	Green (B3) dan SWIR 1 (B11)	((Green – SWIR 1)) / ((Green + SWIR 1))	Mapping the water bodies automatically.
Normalized Difference Tillage Index	NDTI	SWIR 1 (B11) dan SWIR 2 (B12)	((SWIR 1 – SWIR 2)) / ((SWIR 1 + SWIR 2))	Map the built up area and differentiate it from vacant land.
Red-Edge-Based Normalized Vegetation Index	NDVIre	RedEdge 1 (B5) dan Red (B4)	((RedEdge 1 – Red)) / ((RedEdge 1 + Red))	Mapping vegetation automatically.

Source : Osgouei, Kaya, Sertel, & Alganci, 2019

Table 1. 5 Sentinel-2A Band

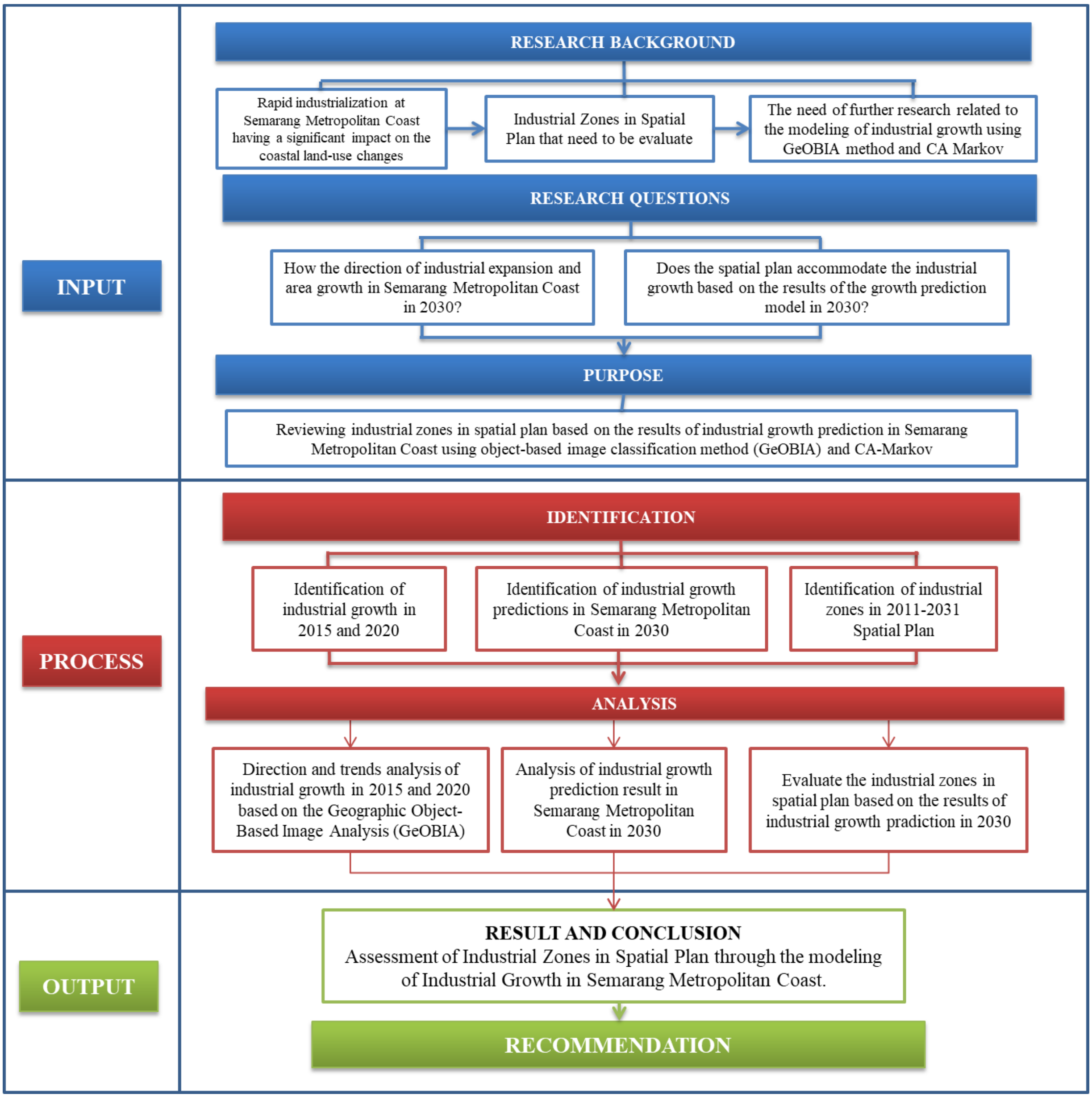
Sensor	Band Number	Band	Sentinel-2A		Sentinel-2B		Resolution (meter)
			Central wavelength (nm)	Bandwith (nm)	Central wavelength (nm)	Bandwith (nm)	
Sensor	B3	*Green*	560.0	35	559	35	10
	B4	*Red*	664.5	30	665	30	10
	B5	*Vegetation Red Edge*	703.9	15	703.8	15	20
	B11	*SWIR*	1613.7	90	1610.4	90	20
	B12	*SWIR*	2202.4	180	2185.7	180	20

Source : Sentinel-2 User Handbook, 2019

1.7.3. Analysis Techniques

The analysis technique used in this study consist literature review related to the growth of industrial locations; identify issues and problems in the Semarang Metropolitan Coast related to the industrial growth; determine the research problem; modeling the industrial land cover classification using GeOBIA Method combines with manual interpretation and prediction of industrial growth and distribution using CA-Markov Model; evaluate the industrial zones in the 2011-2031 spatial plan based on the results of the 2015-2020 industrial growth model; assessment of the industrial zones on the spatial plan based on the industrial growth prediction model in the Semarang Metropolitan Coast in 2030. The process of the analysis phase is listed in the analytical framework in Figure 1.3.

Figure 1. 3 Research Analysis Framework

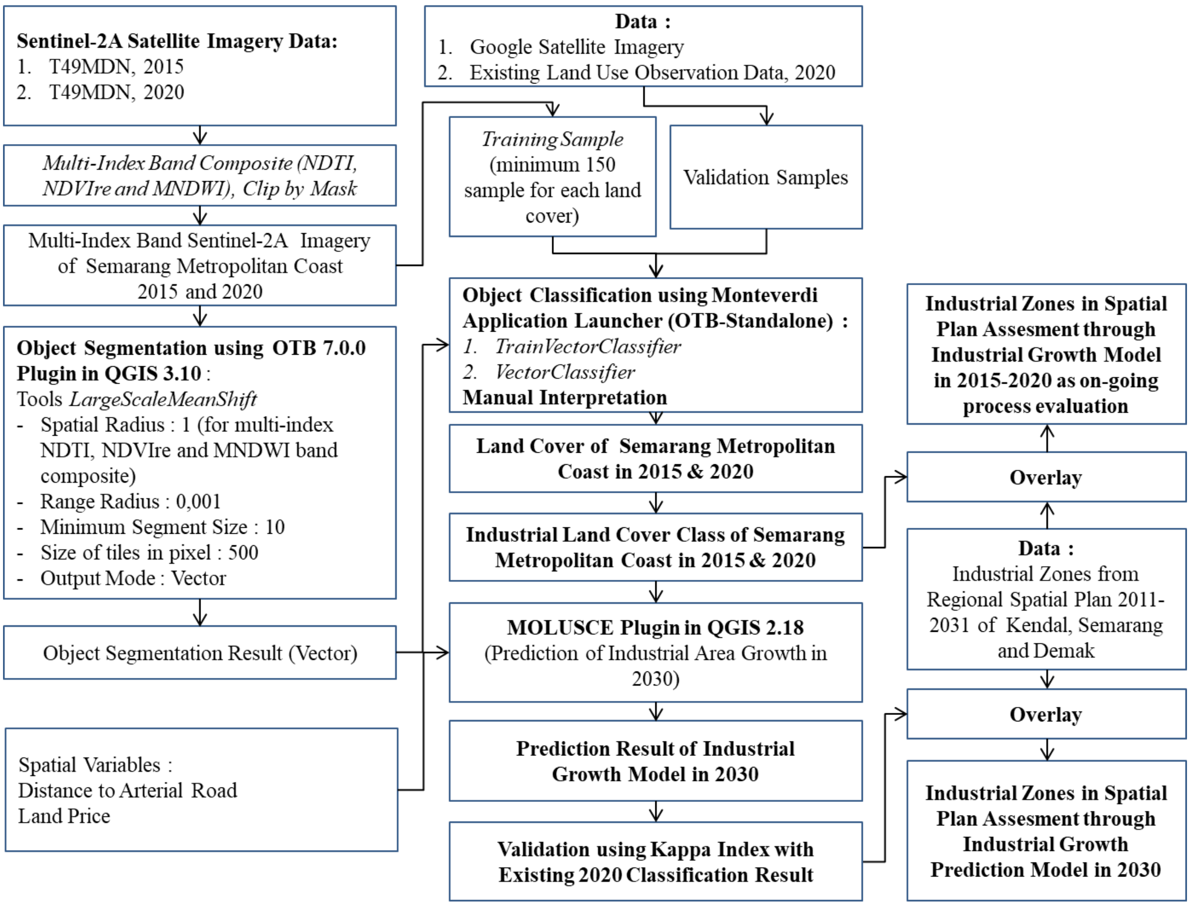


Source : Author's Analysis, 2020

1.8. Framework

This study uses sentinel-2A satellite image data of the T49MDN code for 2015 and 2020 which is processed through the NDTI NDVIre and MNDWI multi-index composite band and radiometric correction. The stages of object segmentation are done using the Orfeo Toolbox Plugin in the QGIS application 3.10. After going through the segmentation stage, the next stage is object classification using vector classifier in monteverdi application launcher on OTB-Standalone. The stages of object classification are done using input training samples and validation samples of 40 points based on the results of field observations. After that, the prediction is done using the MOLUSCE plugin in QGIS 2.18 with 2 iteration simulations to produce growth predictions in 2030. This prediction stage uses spatial variable input in the form of land prices, distance to the arterial road network. Validation is based on the kappa index. The assessment is based on an industry growth overlay with a higher kappa index with the industrial zones in spatial plan. The framework of this study can be seen in Figure 1.4.

Figure 1. 4 Framework



Source : Author's Analysis, 2020

1.9. Systematics Writing

The systematic writing of this study consists of five chapters as follows :

CHAPTER I INTRODUCTION

This chapter contains the background, research problems, research objectives and objectives, the scope of the research both the scope of the area and the scope of the substance, the benefits of research, research methods, frameworks, data collection and analysis methods (including analytical frameworks).

CHAPTER II LITERATURE REVIEW

This chapter contains dialogue between the literature related to the concept of industrial location growth, type of industry, industrial agglomeration, spatial transformation of industrial growth, GeOBIA Method in the context of urban and regional planning, the application of the GeOBIA Method in land use/land cover classification and the literature synthesis.

CHAPTER III GENERAL DESCRIPTION

The third chapter contains an overview of research in general. This chapter will detail the profile of study areas related to aspects of administrative locations as well as profiles of industrial locations in the Semarang Metropolitan Coast and industrial zones in the 2011-2031 spatial plan.

CHAPTER IV IDENTIFICATION AND ANALYSIS OF INDUSTRIAL AREA GROWTH MODEL IN SEMARANG METROPOLITAN COAST

This chapter discusses the identification and analysis of industrial growth models in 2015 and 2020, assessment of industrial zones based on industrial growth model in 2015 and 2020, analysis of industrial growth prediction in 2030 and assessment of industrial zones in spatial plans based on the industrial growth model.

CHAPTER V CONCLUSION AND RECOMMENDATION

This chapter contains conclusions and recommendations related to the results of the assessment of industrial zones in the 2011-2031 spatial plan based on the results of industrial growth model in Semarang Metropolitan Coast and relatied to the methods that have been used in this study and recommendations related to further studies.