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Dynamics of Land Use Changes Around Toll Exit TollRoad, Batang District

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Abstract

Development of tollroad infrastructure is the government's priority to increase the mobility of goods and economy in the region. But be aware that there will be changes in land use, especially in the exit toll, It will trigger a new growth centre and land-use changes have occurred in the areas from agricultural land use changed to be non-agriculture land use. This research was located in the Batang Toll exit, Batang Regency with the objective is to determine the dynamics of tollroad development on land-use change. This research will use the GIS method in analyzing land-use change. Result this research in 2016 – 2022, built-up land increased 43,51 Ha and cropland decreased 41,68 Ha. The construction of toll exits has significantly changed in the area on the main route. The positive thing that is obtained is that accessibility between regions becomes easy, both in mobilizing service goods and community connectivity.

Keywords: LULC; GIS; Transportation.

Introduction

Land use change is increased of land use from one type to other type and followed by reduction of the other type land use from a certain period of time, or change in the functioning of a land in different period of time (Wahyunto, 2001). Land use is closely linked to human activities and nature. Land use and cover changes alter the structure and function of ecosystems, which can threaten biodiversity, thereby leading to reduced provisioning of ecosystem services and greatly altering ecosystem service values (Alam, Bhat, & Maheen, 2020; Crespin & Simonetti, 2016; Foley et al., 2005; Hou, Wu, & Xie, 2020; Lawler et al., 2014; Wang et al., 2021).

The factors of land use change are politics, economy, demographics and culture. The political aspect is the policy made by decision makers that influences the pattern of land use change. Economic growth, changes in income, and consumption are also contributing factors to changes in land use. For example, the increasing need for living space, transportation, and recreation will impact of land use changes (McNeill et al., 1994).

There are several factors that are the impact of land use change, such as the expansion of city, rejuvenation of the city, expansion of infrastructure network of the transportation network, as well as the growing and loss of certain activities (Bourne, 1982).

Human activities, including urbanization and land development have promoted the Land-Use and Land-Cover Change (LUCC) process worldwide (C. Liu et al., 2020; Y. Liu, Feng, Zhao, Zhang, & Su, 2016; Maes et al., 2012; Mishra, Rai, & Rai, 2020), which has impacted no exeptions in exit tollroad. Land use change is the way in the process of "land acquisition-urban sprawl, to land revenue-urban construction, to land acquisition again" (Zhang & Xu, 2017).

Changes in LULC reflect the continuous processes induced either by anthropogenic factors or natural phenomena (Ellis & Ramankutty, 2008; Sarma et al., 2008). This is same as what happened in exit tollroad Batang district. It was caused by development of exit tollroad and land use change is happen from agricultural land use changed to be non-agriculture land use. In this study it will be known how much area of land use changes occurred before and after the development of exit tollroad in Batang district. It will analyzing vegetation dynamics (Reddy & Prasad, 2018), and crop mapping (Arvor, Jonathan, Meirelles, Dubreuil, & Durieux, 2011) land use classifications such as built areas. After that it will be conducted correlation analysis related to tollroad development effect on land-use change.

In this study, we conducted to know about the effect of tollroad development before exit tollroad construction project in 2016 until after opened in 2022. Exit tollroad in Batang district is part of the Semarang-Batang Toll Road and the total length is 75 Km. The tollroad project began construction with ground breaking by President Joko Widodo on 17 June 2016 and officially finish 20 December 2018. To our knowledge very few studies have been conducted concerning landuse change in exit tollroad.

Research Method

This study utilized types of data land-use remote image from google earth 6 year period, which is in 2016 until 2022. Data taken from recorded google earth pro in period 2016 - 2022 on 8 Juni 2022, 18 Juni 2019, 7 Juni 2018, 17 Mei 2017, and 16 Juni 2016. We used ArcMap GIS software version 10.8 (ESRI, Redlands, CA, USA) to analyze our land-use data with the visualization manual interpretation method after that we rectify all of the land-use remote image from google earth.

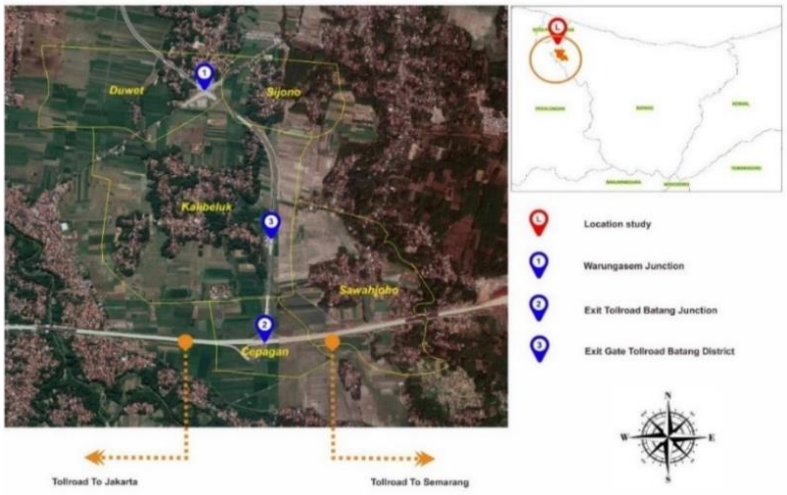

Figure 1. The Proportion Of Each Section

About deliniation location study, we used village administration boundaries from central java province 2009 - 2029 spatial plan. Because location study has many wetlands, we use many categories about wetlands (cropland, woodlands, and grass land). The classification of land use in this study divided into 6 categories (table 1). The dynamic information on land use area over a 6 year period was calculated using the calculated geometry in ArcGIS software version 10.8.

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Finally, we known land-use change map and effect related to tollroad development on land-use change.

Table 1
The Classification Of Land Use

No	Categories	Categories Definitions
1	Cropland	Includes paddy field, non-irrigated farmland
2	Woodland	Includes organic forest, shrubbery, woodland, others
3	Grass land	Includes three coverage types of high, medium, and low
4	Built-up land	Includes urban land residential land, urban land, rural residential land and other built-up land
5	Water bodyWetland	Includes natural and artificial rivers, fishery reservoirs and lakes Includes tidal flats, alluvial flats, and shallows
6	Unused land	Includes sand, saline, marshes, barren lands, others

Source: Analysis, 2023

Results & Discussion

Land Use Change 2016 – 2022 In Exit Tollroad, Batang District

This analysis explains the dynamics of land change based on categories and areas. Based on the analysis results of land use change in 2016 – 2019, built-up land increased by 33,74 Ha, and cropland decreased by 32,45 Ha (table 3). This happens because the development of the exit toll road needs the acquisition of land to convert to built-up land. In 2016, most of the land used there was cropland and grassland (table 2) before the development project exited Tollroad. In 2016, the non-built land category was still dominant compared to the built category, but due to the construction of toll exits, a land change began in 2017.

Table 2
Land Use Change Before The Development Project In 2016 – 2019 (Ha)

No	Categories	2016	2017	2018	2019
1	Built-up land	70,06	76,35	96,8	103,8
2	Cropland	334,9	324,67	302,76	302,45
3	Grass land	97,34	91,7	86,13	83,27
4	Unused land	-	9,69	17,31	13,63
5	Water body Wetland	1,84	1,84	1,83	1,83
7	Woodland	10,41	10,3	9,72	9,58
Total		514,55	514,55	514,55	514,55

Source: Analysis, 2023

After 2016, the Portland acquisition was in progress, and land use change occurred. Figure 2 shows the development project exit tollroad location study still needs to begin. Mostly, there is cropland, and the concentration of built areas is still centered on existing settlements. Non-built land category began to turn into built-up land due to the start of exit toll construction (+ 6.29 Ha). It can be compared in Figure 2 and Figure 3 there are differences in land change.

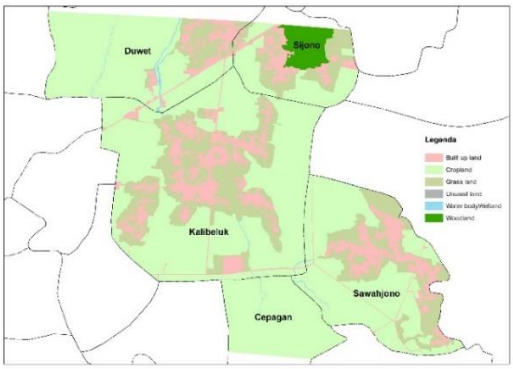

Figure 2. Landuse Change in 2016

In 2017, the development of toll roads in consolidation and acquisition of land was introduced. It can be seen on data from recorded Google Earth 17 Mei 2017, and there needs to be tollroad infrastructure development begins. There appears to be a lot of unused land, and the development progress is fast in 2017 – 2019.

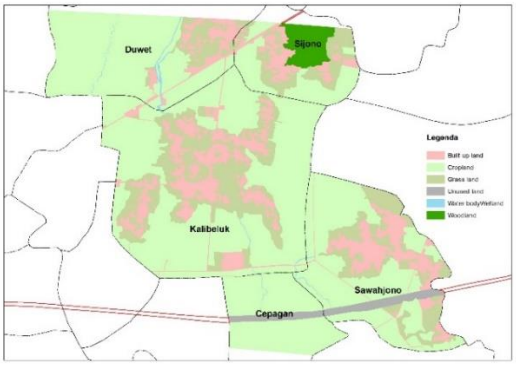

Figure 3. Landuse Change in 2017

In 2018, built-up land significant increase reached (+) 20,45 Ha, and cropland decreased (–) 21,91 Ha. It has influence of development exit tollroad construction and supporting facilities such as toll gates and toll road office. The least change in land use is waterbodywetland (-0,01). In periods 2016 – 2019 there is an increase in the area built-up land and unused land. This indicates that there is a change in land use occurring from non built-up land to build up land.

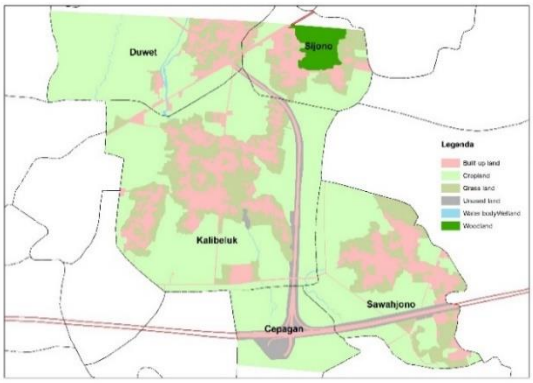

Figure 4. Landuse Change in 2018

Finnaly in 2019, all of the development of tollroad is done and already in use. In period 2018 – 2022, land use change mostly in built-up land increased 43,51 Ha. Unused land increased 13,63 Ha because the development tollroad is done and only left on tollroad safety lanes on the left right tollroad (table 3).

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Table 3
Land use change in 2016 and 2022 (Ha)

No	Categories	2016	2022	Change Area
1	Built-up land	70,06	113,57	(+) 43,51
2	Cropland	334,9	293,22	(–) 41,68
3	Grass land	97,34	82,77	(–) 14,57
4	Unused land	0	13,60	(+) 13,63
5	Water bodyWetland	1,84	1,82	(–) 0,02
7	Woodland	10,41	9,58	(–) 0,83
Total		514,55	514,55	514,55

Source: Analysis, 2023

As you know this toll road is used to facilitate the transfer of goods and people so that the economy can grow in Batang District. Near exit tollroad there is a batik market sentono and certainly have benefit from the development exit tollroad, batang district. Distribution of land use change can be seen in Figure 5.

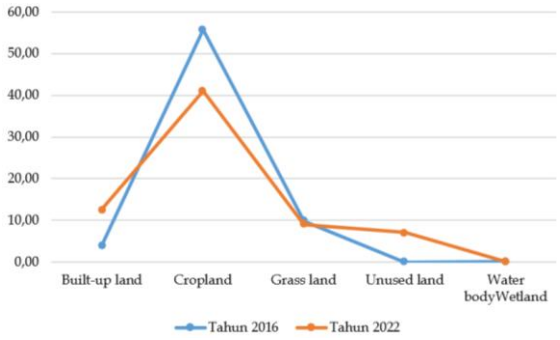

Figure 5. Distribution of Land Use Change 2016-2022

The majority of the spatial characteristics of land use change on main roads and existing settlements. Around the Warungasem junction are many new buildings, such as educational facilities (pipes), government, and trade and services. There is a map of land use in 2022 (figure 6). Based on its development, only the main road has a very significant change due to the strategic location that allows the development of certain activities.

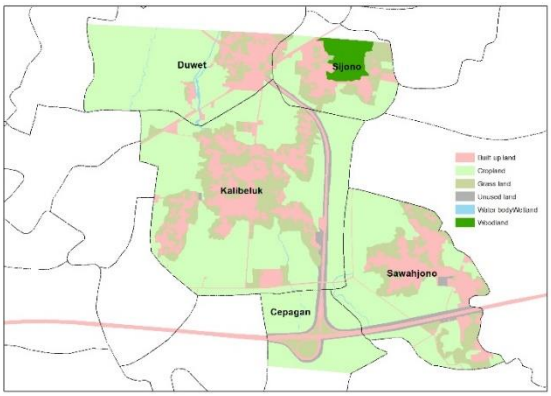

Figure 6. Landuse Change in 2022

If land use changes are detailed by sub-district in 2016 – 2022 (table 4), majority for built up land increased in Kalibeluk 11,37 Ha while cropland majority decreased in Cepagan 12,20 Ha. This can be understood because Warungasem district is the most affected area by toll development 82,56%. Warungasem sub-district has 4 affected villages with the largest area is Kalibeluk village 215,45 Ha and the smallest area is Cepagan village 44,64 Ha. Grassland in Kalibeluk village most decreased in 2016 – 2022 (-7,81 Ha) and only 1 village that has grassland increased in Cepagan (+3,62 Ha).

Some existing settlements following the theory of open country or trade center community, settlements are scattered in the agriculture and between settlements with each other are connected by main roads. While others follow the theory of line village community where land the settlement extends to the left right of the road. Land use for trade and services are along the highway like at the Warungasem junction.

The Effect Of Exit Tollroad Development On Land-Use Change

In this section, we want explained about land use change in exit tollroad around 150 meter full buffer (left and right) in 2016 - 2022. Land use changes certainly have a positive and negative impact. The positive impact are the economy around exit toll growth, accessibility of goods and services is increasing, land prices are rising, and new growth centers around exit toll. The negatif impact are land use change from non built up land to built up land, so it will impact in water catchment area and food reserves because so many conversion cropland.

According to analysis in period 2016 – 2022 around 150 meter, built up land increased in tollroad lanes and around Warungasem junction. In Sibeluk village, built up land area majority conversion in there because the main of development exit tollroad infrastructure is there (figure 6). Landuse decreased around 150 meter in exit tollroad is Cropland (-) 14,71 Ha, Grass land (-) 0,94 Ha, and Water bodyWetland nothing change, While landuse increased is built up land (+) 8,61 Ha and unused land (+) 7,04 Ha. Around Warungasem junction in 2016, area built land is few and dominated by cropland/grassland. The progres development exit toll finish in 2018 and built up land start popping up. Finnaly in 2023 until now built up land is majority in there because accesibillity and great location.

Table 4
Land use change based District in 2016 and 2022 (Ha)

2016	Built-up land	Cropland	Grass land	Unused land	Water bodyWetland	Woodland	Total
Pekalongan Selatan	**8,63**	**70,58**	**9,35**	**0**	**1,2**	**0**	**89,75**
Duwet	8,63	70,58	9,35	0	1,2	0	**89,75**
Warungasem	**61,43**	**264,31**	**88**	**0**	**0,65**	**10,41**	**424,8**
Cepagan	0	44,52	0	0	0,12	0	**44,64**
Kalibeluk	33,47	132,94	48,74	0	0,3	0	**215,45**
Sawahjoho	18,99	68,28	25,37	0	0,23	0	**112,86**
Sijono	8,97	18,57	13,89	0	0	10,41	**51,85**
Total	**70,06**	**334,89**	**97,35**	**0**	**1,85**	**10,41**	**514,55**
2022	**Built-up land**	**Cropland**	**Grass land**	**Unused land**	**Water bodyWetland**	**Woodland**	**Total**
Pekalongan Selatan	**14,35**	**67,92**	**6,24**	**0,06**	**1,18**	**-**	**89,75**
Duwet	14,35	67,92	6,24	0,06	1,18	-	**89,75**
Warungasem	**90,18**	**234,5**	**76,5**	**13,55**	**0,65**	**9,42**	**424,80**
Cepagan	5,11	32,32	3,62	3,46	0,12	-	**44,64**
Kalibeluk	44,84	124,24	40,93	5,13	0,3	-	**215,45**
Sawahjoho	27,28	60,55	20,42	4,39	0,23	-	**112,86**
Sijono	12,95	17,39	11,53	0,57	-	9,58	**51,85**
Total	**104,53**	**302,42**	**82,74**	**13,61**	**1,83**	**9,42**	**514,55**

Source: Analysis, 2023

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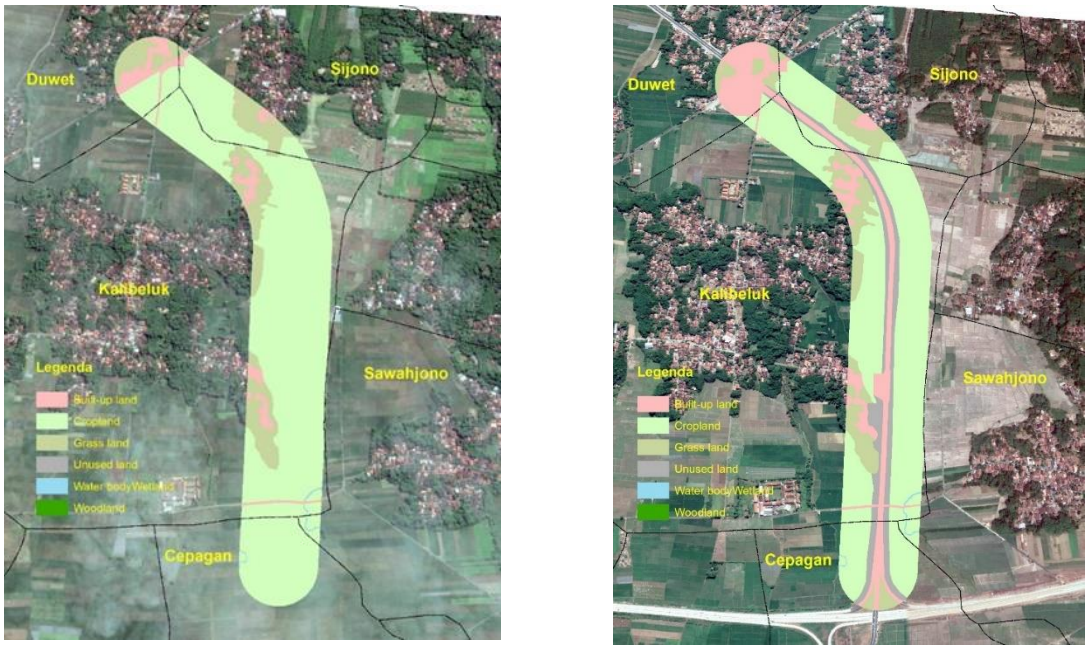

2016 **2022**

Figure 7. Effect Of Exit Tollroad Development On Land-Use Change 2016 – 2022

Fifty data accuracy test points were taken in the observation area to validate. This accuracy test is carried out at points needing correction when digitizing the map. From the calculation of the kappa accuracy test results, 75,55% results are obtained, meaning that the results in digitization are substantial aggrement and can be used (Viera & Garrett, 2005). For the most error data, the cropland category becomes build-up land (table 5).

Table 5
Accuracy Assesment

No	Categories	Built-up land	Cropland	Grass land	Unused land	Water bodyWetland	Woodland	Total (User)
1	Built-up land	12	5	2				**19**
2	Cropland		12				2	**14**
3	Grass land			3				**3**
4	Unused land				4			**4**
5	Water bodyWetland					2		**2**
6	Woodland						8	**8**
Total (Producer)		**12**	**17**	**5**	**4**	**2**	**10**	**50**

Source: Analysis, 2023

User Accuracy Calculation

Built-up land = 12/19 x 100 = 63,16%
Cropland = 12/14 x 100 = 85,71%
Grass land = 3/3 x 100 = 100%
Unused land = 4/4 x 100 = 100%
Water bodyWetland = 2/2 x 100 = 100%
Woodland = 8/8 x 100 = 100%

Producer Accuracy Calculation

Built-up land = 12/12 x 100 = 63,16%
Cropland = 12/17 x 100 = 70,59%
Grass land = 3/5 x 100 = 60%

Unused land = 4/4 x 100 = 100%
Water bodyWetland = 2/2 x 100 = 100%
Woodland = 8/10 x 100 = 80%

Kappa Coefisien

$$= \frac{(50 \times 41) - \{(12 \times 19) + (17 \times 14) + (5 \times 3) + (4 \times 4) + (2 \times 2) + (10 \times 8)\} \times 100}{2500 - \{(12 \times 19) + (17 \times 14) + (5 \times 3) + (4 \times 4) + (2 \times 2) + (10 \times 8)\}}$$
$$= \frac{2050 - 581}{2500 - 581}$$
$$= \mathbf{76,55\%}$$

Conclusions

Land use change in exit tollroad, Batang District happen because trans java tollroad policy. This policy is make conversion of land from agriculture to built-up land. Despite the negative side land use change, trans java tollroad have a positive side that is economy around exit toll growth, accessibility of goods and services is increasing, land prices are rising, and new growth centers around exit toll. This study has shown that land use change in 2016 – 2022, built-up land increased 43,51 Ha and cropland decreased 41,68 Ha. This happens because of the development exit tollroad need acquisition of land to convert to built-up land. The spatial characteristics about land use change majority is on around exit tollroad, main roads and existing settlements.

The effect of exit tollroad development on land-use change 2016 – 2022 around 150 meter buffer is built up land area majority conversion in Sibeluk Village because there is the main of development infrastructure. Overall, landuse decreased around 150 meter in exit tollroad is Cropland (-) 14,71 Ha, Grass land (-) 0,94 Ha, and Water bodyWetland nothing change, While landuse increased is built up land (+) 8,61 Ha and unused land (+) 7,05 Ha. Now in 2023 built up land is majority in there because a strategic location.

The construction of toll exits has significantly changed in the area on the main route. The positive thing that is obtained is that accessibility between regions becomes easy, both in mobilizing service goods and community connectivity. In addition, the selling value of land around the toll exit has a high increase in land value because it has strategic value. What needs to be noted is that there is still a lot of agricultural land around the toll exit that may be converted into built-up land if there is no precise regulation. Of course, this requires a firmness to keep the rice fields sustainable and maintained.

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