The spatial dynamics of the Semarang-Surakarta development corridor: two young metropolitan cities of Central Java, Indonesia

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Abstract: The interactions between metropolitan cities can generate so-called development corridors along the regional lines. In Central Java, three cities, namely Yogyakarta (Jogya), Surakarta (Solo), and Semarang, form a triangular development known as Joglosemar. This study aimed to observe the spatial dynamics of the Semarang-Surakarta corridor, regarding the operation of the new toll road connecting these two cities. Spatial analyses based on the geographic information system (GIS) were applied to observe the land-use change in the corridor. Statistical analyses focused on population shift, the poor, and employment at the sub-district (kecamatan) level. The empirical findings confirm previous studies, in that the regional development follows regional lines along both arterial and toll roads, and the existence of the toll road was the magnet for the development. However, the increase in industrial activities did not always benefit the poor, especially in the sub-districts where industrial activities have been developing in the longer term. For this reason, we recommend that local governments consider how to make the positive impacts of industrial development sustainable. The results of this study are also expected to enrich the literature on the spatial dynamics of a development corridor connecting two medium-sized metropolitan cities in developing countries.

Keywords: spatial dynamics; development corridor; toll road; urbanisation; geographic information system; GIS; urban sustainability; Indonesia.

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1 Introduction

In the last few decades, cities in developing countries have been growing rapidly. Many of these have formed metropolitan cities that consist of one or several cities as the core, and their surrounding regions as hinterlands. This phenomenon indicates an urbanisation process that affects not only the physical features but also the characteristics of the society and culture of their inhabitants. In such a case, urbanisation can be considered a process of social change, whereby communities initially characterised as rural become urban (Soh, 2012). The indicator most often used to measure such change is the increasing proportion of jobs in non-agricultural sectors. The physical indicator most easily seen in the urbanisation process is a shift in land use, with a high rate of land conversion from agricultural to urban activities, like settlements, industry, and trade. While urbanisation has the potential to improve the welfare of a population, if not appropriately managed it can also disrupt lives and environmental sustainability (Von Braun, 2007).

The development of medium and large cities brings changes in the surrounding area due to the high rate of interactions between the central city and its surrounding areas. In European metropolitan cities, these interactions generate development corridors and

public transport links, supported by high-speed public transportation, as clusters of urban development (Hall, 2002). Likewise, in developing countries, the expansion of large cities into their surrounding regions has also occurred (McGee, 1991; Legates and Hudalah, 2014), generating development corridors because of the high level of interaction (Aguilar et al., 2003). In the literature, these corridors are also known as economic corridors (Von Braun, 2007; Garcia-López, 2012; Firman and Fahmi, 2017). Previous studies have also shown that the rapid development of urbanisation in growth corridors may be due to the attractiveness of large cities (Firman, 2009; Sugiri et al., 2015; Setyono et al., 2016; Hudalah et al., 2019). Such development includes not only physical aspects but also social, economic, and environmental aspects. The term commercial corridor was initially used by the Asian Development Bank (ADB) to describe the development of the Greater Mekong Sub-Region (GMS) (Athukorala and Narayanan, 2018), but later this term was used to explain the interactions between metropolitan cities (Budiyantini and Pratiwi, 2016; Shi and Cao, 2019).

Many factors cause the growth of a development corridor, such as the intensity of interaction between metropolises, their size, and accessibility between metropolitan areas, such as road networks (Hall, 2002; Al-Sharif and Pradhan, 2016; Luo et al., 2018). Among these factors, road networks are significant. Changes around the corridor are usually preceded by economic growth, which, in turn, generates activities that are then followed by social and economic changes in the areas influenced by the corridor. With the construction of roads in Danang, Vietnam, there has been a change in community characteristics, including an influx of migrants developing a new retail network, or starting up new business, such as for lodgings, dining, manufacturing, motorbike repair, and language tutoring. There were also land-use changes for a more productive business sector in the form of multi-story, mixed-use buildings called tube houses (Won et al., 2015). The development of the road network was accompanied by property investment, both local and international, and this drove the economy through a variety of programs, such as recreational amenities, a residential complex with tube houses and villas, a golf course, a marina, an amusement park, and an international school (Won et al., 2015).

Some studies on road and economic corridors have been carried out, such as those of Athukorala and Narayanan (2018) and Xu et al. (2019) focusing on regional interconnection and regional economics, Dwyer (2020) on geopolitics of economic corridors as connecting points of strategic value spaces, and Sloan et al. (2019) on trans-Papua as the corridor opening the access to the region and the source of economic prosperity for the surrounding regions. However, how the impacts of development corridors on spatial dynamics that also affect the economy and public policies related to public welfare were has less studied.

The development pattern of the corridors connecting metropolitan cities has also happened in Indonesia. In addition to the development corridor of Jakarta and Bandung metropolitan cities, the two largest metropolitan areas in Indonesia, the growth of the development corridors connecting medium-scale metropolitan cities is also continuing (Buchori et al., 2017). In central Java, development corridors were formed between three young metropolitan cities, namely Yogyakarta, Surakarta, and Semarang, as a development triangle well acknowledged by the acronym Joglosemar (Setyono et al., 2016; Buchori et al., 2017, 2018, 2020). Even though the toll road of Semarang-Surakarta has only been operating for under a year, the spatial dynamics began to change once the road was established in 2007, when land acquisitions began even before the road construction.

The spatial dynamics and other related aspects of the Jakarta-Bandung corridor and its surrounding areas have been widely studied (Firman, 2009; Hudalah et al., 2013, 2019; Octifanny and Hudalah, 2017). In this corridor, a mix of socioeconomic activities has grown, including agriculture, industry, trade, and housing to form strong rural-urban relations blurring the differences between rural and urban areas. Large-scale housing and new town, infrastructure and industrial estate development were the main driving factor (Firman, 2009). However, this may not be the case with the other corridors in Java, such as Surabaya-Malang in the eastern part of Java, and the triangular corridor of Joglosemar in central Java. This study therefore examines the spatial dynamics along the Semarang-Surakarta corridor, especially in areas affected by the new toll road link between these two cities. This toll road mainly connects the cities of Jakarta and Surabaya, the two largest growth centres in Indonesia, as well as the major small and medium cities along the northern coast of Java. The observation is focused on how the new toll road increased the industrial and other urban activities and how they influenced the spatial and socio-economic conditions of the region. The results of this study are expected to enrich the literature relating to the spatial dynamics of development corridors, especially those of medium- and large-scale cities.

2 Urbanisation and development corridors

Urbanisation is an exciting phenomenon in many fast-growing cities in the world, especially in developing countries (Salvati etal., 2013; Liu et al., 2014; Yang et al., 2018), and can be seen as a reflection of the economic development of a region (Berdegué et al., 2015; Wang et al., 2018). Certain cases in China show that urbanisation has been taking place since 1970 and has mainly been driven by financial (economic) and land forces (Feng et al., 2019). In Asian metropolitan cities like Tokyo, Delhi, and Shanghai, urbanisation increases along with the economic development of a city (United Nations, Department of Economic and Social Affairs, Population Division, 2019). In China, an observation of 298 cities shows that the urbanisation rate between 2001–2013 has continued to increase along with the expansion of urban areas (Feng et al., 2019).

Urbanisation concentrated in peripheral areas has formed a new and more complex urban structure (Allen, 2003; Soh, 2012; Shang et al., 2018; Zhang et al., 2019a). The expansion of urban areas to peripheral ones indicates the development of a metropolis (McGee, 1971; Walcott and Pannell, 2006; Pontifex and Silitonga, 2010), and may consist of more than one interconnected cores (McGee, 1971; Lizhu et al., 2013). McGee (1991) found that in urban Asian countries the concept of ‘desakota’ was the basis of Extended Metropolitan Regions (EMR). These have characteristics such as higher population density, agriculture as the main economic activity but the beginning of change to non-agricultural activities, higher mobility and accessibility, increasing interaction between villages and the city, and increasingly mixed land use.

The EMR shapes a structure that combines the urban core, peri-urban zones, and the ‘desakota’ areas, with a mixed-use pattern of urban and rural lands emerging along the transportation routes (McGee, 1991; Lizhu et al., 2013; Shi and Cao, 2019). Urban expansion influences considerable land-use changes in the surrounding areas, and accessibility and transportation have an important role in the direction of land use changes and the shaping of the spatial structure of the metropolitan area (Hudalah et al.,

2014; Al-Sharif and Pradhan, 2016; Caragliu and Del Bo, 2019). A study in the Tabriz metropolitan area of Iran revealed that its development formed an EMR structure influenced by transportation routes. The growth pattern concentrated on suburban areas, and links with transport paths are dominant (Dadashpoor et al., 2019). In the regions of the suburb and outside the cities, the residential areas usually form an agglomeration, while the industrial areas tend to be dispersed, following main roads with better accessibility (Dadashpoor et al., 2019). Various factors influence the formation of a metropolitan area, such as urban spill-over, the spread of population from the city centre and in-situ industrialisation in suburban areas (Shi and Cao, 2019). In the development of the Beijing metropolitan area, both factors played an important role (Shi and Cao, 2019) in the expansion of suburban areas and urbanisation, which in turn developed the metropolitan area.

Industrial development is one strategy that can be used to accelerate the economic growth of a city or region (Murphy, 2007; Ma et al., 2018). Compared to others, it can deliver faster and more significant growth in the regional economy (Inouye et al., 2015; Hart, 2018). Empirical facts in European cities show that since the beginning of the industrial revolution, regional economies have significantly improved, and urbanisation within them has accelerated (Taubenböck et al., 2012; Wang et al., 2018; Zhang et al., 2019a). Thus, industrialisation in suburban areas has impacted the process of urbanisation.

The high price of land in city centres forces industries to develop in suburban areas (Murphy, 2007; Li et al., 2019), meaning that urbanisation in these areas grows faster than in city centres (McGee, 1971; Walcott and Pannell, 2006; Legates and Hudalah, 2014; Guo et al., 2018). At the same time, urban facilities and low land prices in suburban areas benefit migrants. Industrialisation also triggers changes in livelihoods from economic activities in agriculture to industry (Chen and Zhao, 2017; Wijaya et al., 2018). In this case, the indigenous or local community considers that industrialisation is a consequence of regional development in their environments (Long et al., 2009; Han et al., 2012).

Urbanisation in suburban areas blurs the border between rural and urban areas (Long and Zhang, 2012; Song et al., 2012), and this border becomes less clear with rapid economic growth and the intensive development of infrastructure, especially roads and modes of transportation (Hudalah et al., 2019). Moreover, industrial development as the basis of economic activity in rural and suburban areas drives changes in land use from rural to urban (Zhang et al., 2019b), and the development of road systems accelerates the process of change.

The development of road networks is often linked to the phenomena of urbanisation and industrialisation (Han et al., 2012; Komlos and A'Hearn, 2017; Liu et al., 2018). Several studies have shown that an increasing number of road networks is correlated with the rate of urbanisation (Zhang et al., 2017; Yudhistira et al., 2019). The road network is a kind of transport infrastructure which acts as a vein in the system of urban and regional development (Luo et al., 2018; Yudhistira et al., 2019). One example of this is Jakarta Metropolitan Area (JMA), where increasing access to roads and railways has driven population growth in suburban areas (Yudhistira et al., 2019). This increased access has also influenced changes in the spatial structure of JMA, as the road networks determine the direction of urban development (Fahmi et al., 2016; Yudhistira et al., 2019). The land use change around the road networks has also affected the non-agricultural activities of the community. From 2000 to 2010, the agricultural productivity of the community

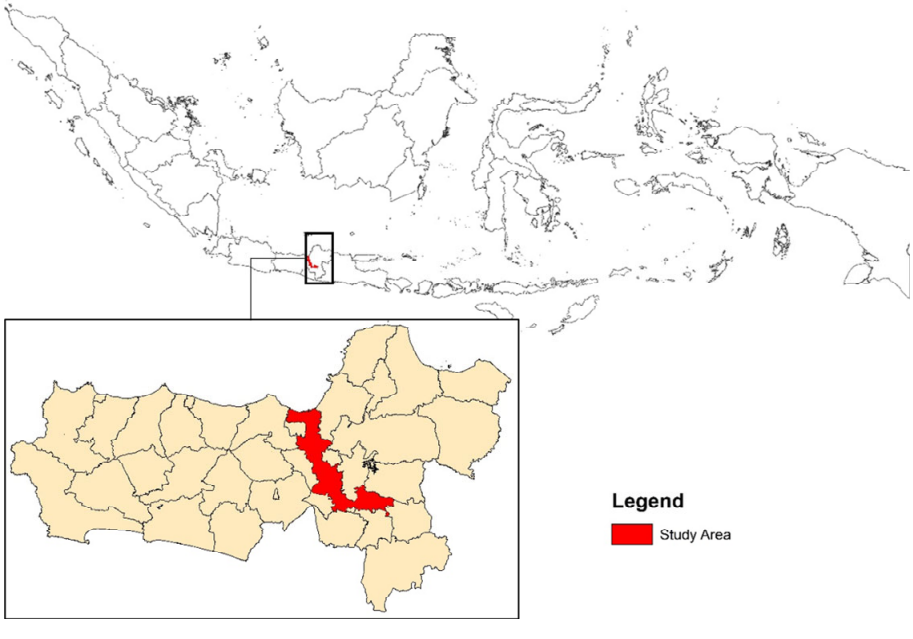
around the highways and toll roads was in decline (Yudhistira et al., 2019), and there was also a correlation between accessibility and urbanisation (Yudhistira et al., 2019). In this regard, the development of transport infrastructure like toll roads, highways, and railways functions as a magnet for urban growth and development.

The development of transport infrastructure affects the welfare level of an area (Zia et al., 2013; Van Damme et al., 2016), and an area which has, or is passed by, transport infrastructure is usually more developed and has a higher level of welfare than others (Duran-Fernandez and Santos, 2014). According to the study of a metropolitan case in Mexico, regions with more road networks were recognised as more developed than those with fewer road networks (Duran-Fernandez and Santos, 2014). In this way, the transport infrastructure may stimulate the economic development of the region.

3 Data and methods

This study used the positivistic approach by observing the selected phenomenon and comparing it with current theories or concepts. The study area covers sub-districts which are passed by the artery and toll roads connecting Semarang and Surakarta (see Figure 1). The analysis used statistical and spatial data (land use maps for 2008 and 2018) gathered from responsible institutions and established from visual observation of the study area. The land use maps were developed from satellite images (Landsat5 and Google Earth), delineated using a supervised classification method. The analysis of land use change was focused on the extension of the non-industrial built-up areas and the establishment of industrial activities. It observed how industry has become a magnet for the surrounding areas. On this basis, land use was divided into three categories: non-industrial built-up area, industrial area, and unbuilt-up area.

Figure 1 The study area (see online version for colours)



Furthermore, this study used kernel density analysis (KDA), a type of geographic information system (GIS) spatial analysis, to observe the relationships between the development of the Semarang-Surakarta toll road and the increase in population, using sub-district population data for 2008 and 2018. The KDA used a radius of 7,000 km, to identify areas with significant changes in population density, and locations which might potentially become new settlement centres between 2008 to 2018.

As for the statistical analysis, this aimed to reveal the life changes of the people living in the areas through which the artery and toll roads pass. They were compiled from the Statistic Office's data of the respective regencies/cities (kabupaten/kota). The indicators generally used to measure urban dynamics are the percent of urban to total population (Han et al., 2012), the percentage of built-up area (Banzhaf et al., 2013; Rukmana and Rudiarto, 2016; Buchori et al., 2017; Duvernoy et al., 2018), and population density (Banzhaf et al., 2013; Lizhu et al., 2013; Buchori et al., 2017). This study used these indicators to examine the spatial dynamics in every sub-district during the period 2008–2018. However, although this analysis was detailed at the sub-district level, unfortunately the availability of the required data was relatively limited. This was because the study area covered 29 sub-districts belonging to three cities (Semarang, Salatiga, and Surakarta) and the three regencies of Semarang, Boyolali, and Kartosuro. These provided different levels of detail in their data, particularly those at sub-district level. It was often found that specific data obtained by some cities/regencies were not available in others. According to these limitations, the statistical data used for the analyses were population, poor persons, and non-agriculture employment by sub-district, as these data were provided for all regencies/cities during the survey. The data for population by sub-district were provided for 2008 and 2018, but the data for percent of urban population were based on the percentage of non-agriculture employment to total employment on different dates, as shown in Table 1.

Table 1 Data on non-agriculture employment by sub-district in each city/regency

No.	*Regency/city*	*Years*
1	Semarang City	2010 and 2018
2	Semarang Regency	2005 and 2018
3	Salatiga City	2008 and 2012
4	Boyolali Regency	2008 and 2015
5	Karanganyar Regency	2008 and 2010
6	Surakarta City	2010 and 2015
7	Kartasura City	2008 and 2018

Table 2 Data on poor persons by sub-district in each city/regency

No.	*Regency/city*	*Years*
1	Semarang City	2008 and 2018
2	Semarang Regency	2008 and 2018
3	Salatiga City	2007 and 2015
4	Boyolali Regency	2008 and 2018
5	Karanganyar Regency	2008 and 2018
6	Surakarta City	2010 and 2018
7	Kartasura City	2008 and 2018

Furthermore, the data on poor persons by sub-district were also based on different dates due to data availability, as shown in Table 2. According to this limitation, the analysis was based on the annual increase or decrease in the number of poor persons by sub-district.

The analysis of how spatial dynamics was affected by the increase in industrial activities focused on the ten large sub-districts with the highest growth in industrial areas between 2008–2018. It aimed to explain how the rise in industrial area influenced the indicators of spatial dynamics, namely the shift of population density and built-up area, the change in the proportion of urban employment to total employment, and the increase in the number of poor persons.

4 Results

The Semarang-Surakarta toll road began construction on March 1st, 2009 and was completed on December 20, 2018. It was planned to pass through three cities (Semarang, Salatiga, and Surakarta) and three regencies (Semarang, Boyolali, and Sukoharjo). The toll road is part of the Trans Java toll road connecting the Semarang toll road with the Surakarta-Ngawi toll road. The Semarang-Surakarta toll road project consists of five sections for completion over nine years (Table 3). There are ten toll gates in the study area, located in the sub-districts of Semarang Barat (Semarang City), Gajah Mungkur (Semarang City), Tembalang (Semarang City), Ungaran Timur (Semarang Regency), Bawen (Semarang Regency), Tingkir (Salatiga City), Mojosongo (Boyolali Regency), Banyudono (Boyolali Regency), Ngemplak (Boyolali Regency), and Kebakkramat (Karanganyar Regency).

Table 3 The development sections of the Semarang-Surakarta Toll Road

No.	*Section*	*Length*	*Operated on*
1	Section 1 (Tembalang-Ungaran)	16.3 km	November 11, 2011
2	Section 2 (Ungaran-Bawen)	11.3 km	April 4, 2014
3	Section 3 (Bawen-Salatiga)	17.6 km	September 25, 2017
4	Section 4 (Salatiga-Boyolali)	22.4 km	December 20, 2018
5	Section 5 (Boyolali-Kartosuro)	11.1 km	December 20, 2018

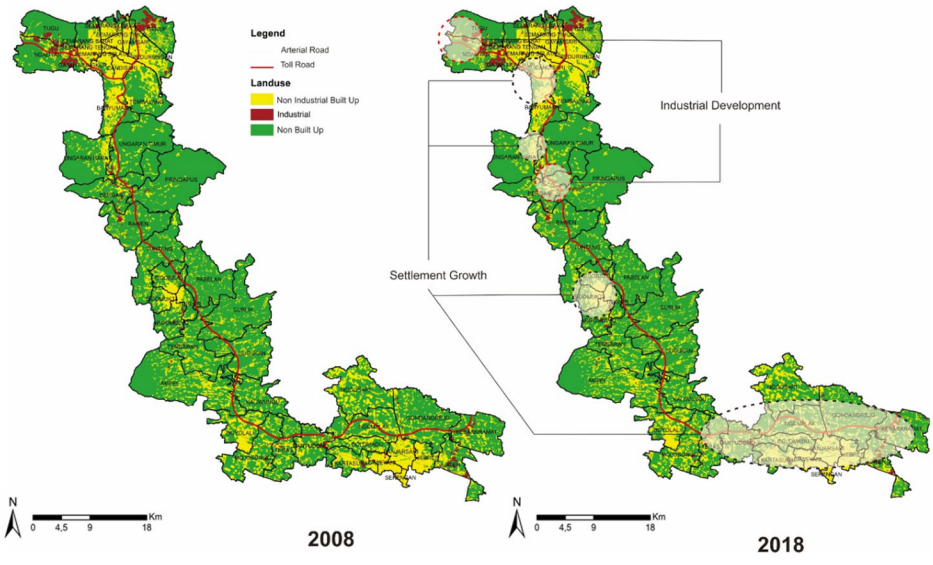
Source: Bina Marga Agency, 2018

Although the development of the toll road was a new issue at the time of construction, it has influenced the direction of spatial development in the traversed areas. Based on image data processing of the satellite image for 2010 and 2018, two major changes can be seen regarding industrial and residential developments. Figure 2 shows that the growth in industrial development was centred on the northern part of the study area, while the growth in settlement development was concentrated more in the middle and southern parts. The growth of residential areas in the southern part was greater than those in the central part of the study area. The circled areas were the growth areas experiencing an increase of built-up areas, either as a non-industrial, industrial, or both areas.

Table 4 shows the land-use change by sub-district for three land-use categories: unbuilt-up area, built-up area, and industry. The shaded cells in the table show the big ten of sub-districts in the increase of non-industrial built-up and industrial areas. The

unbuilt-up area declined 3,988.17 Ha and to become built-up area (3,642.85 Ha) and industry (345.32 Ha). The increase in industrial land use of approximately 10% from the built-up area indicated that although the development of industrial activity in the study area was significant, it was concentrated in several sub-districts.

Figure 2 Land-use changes between 2008–2018 (see online version for colours)



Source: developed from satellite images (Landsat5 and Google Earth)

The development of the non-industrial built-up area showed a different pattern. The five highest increases occurred, respectively, in the sub-districts of Tembalang (Semarang City), Pedurungan (Semarang City), Genuk (Semarang City), Kartosuro (Sukoharjo Regency), and Gondangrejo (Karanganyar Regency). This indicates that the non-industrial built-up areas, mostly in the residential areas, grew in the suburban areas of the cities of Semarang and Surakarta. The development of the education area in Tembalang, indicated by the presence of Diponegoro University and Semarang State Polytechnic, was the driving factor for the increase in built-up areas in this sub-district. Moreover, the Semarang Master Plan (Rencana Tata Ruang Wilayah/RTRW) for the development of residential areas in the Pedurungan sub-district has encouraged developers to build new residential areas there. It is interesting that the built-up areas also grew significantly in two sub-districts of Boyolali Regency, Mojosongo and Teras, which are in the middle of the corridor. Remarkably, the location of these two sub-districts was separate from the Ampel sub-district which experienced the highest increase in industry in Boyolali Regency. However, the growth of industrial land use was relatively higher compared to other sub-districts in Boyolali.

Figure 3 shows the spatial distribution of the increase of non-industrial built-up and industrial areas. Although in detail they had different patterns, their spatial dynamics were generally quite similar in that they occurred mostly in the northern and southern parts of the study area. The centre experienced less spatial change in several sub-districts of Boyolali Regency because the supporting factors for the development of each region were not the same.

Table 4 Land-use change by sub-district (2008–2018)

	City/regency	Sub-districts (Kecamatan)	Area (Ha)	Land-use 2008 (Ha)			Land-use 2018 (Ha)			Land-use change 2008–2018 (Ha)		
				Unbuilt-up	*Non-industrial built-up*	*Industry*	*Unbuilt-up*	*Non-industrial built-up*	*Industry*	*Unbuilt-up*	*Non-industrial built-up*	*Industry*
1	Semarang City	Banyumanik	3,055.72	1,156.75	1,877.64	21.32	1,154.29	1,880.10	21.32	–146.65	146.65	0.00
		Candisari	703.00	40.74	662.27	–	40.74	662.27	–	–0.01	0.01	0.00
		Gajah Mungkur	959.72	206.58	753.15	–	204.75	754.98	–	–24.60	24.60	0.00
		Gayamsari	612.80	146.24	464.27	2.29	140.83	464.27	7.70	–18.34	12.93	5.41
		Genuk	2,709.31	1,507.47	731.04	470.80	1,415.00	811.85	482.46	–217.63	205.97	11.66
		Ngaliyan	4,428.79	3,117.40	866.00	445.39	3,024.30	912.73	491.77	–176.35	129.97	46.38
		Pedurungan	2,187.88	491.80	1,644.34	51.74	479.49	1,654.74	53.65	–298.78	296.87	1.91
		Semarang Barat	2,209.33	995.12	1,119.33	94.88	986.46	1,127.99	94.88	–24.56	22.79	1.76
		Semarang Selatan	621.89	13.63	608.26	–	13.63	608.26	–	0.00	0.00	0.00
		Semarang Tengah	535.40	7.31	528.08	–	7.31	528.08	–	0.00	0.00	0.00
		Semarang Timur	559.44	48.30	488.54	22.60	48.28	488.57	22.60	–0.51	0.51	0.00
		Semarang Utara	1,112.71	521.69	523.60	67.41	520.70	524.59	67.41	–11.89	2.56	9.33
		Tembalang	3,980.06	2,453.52	1,526.11	0.43	2,448.51	1,530.78	0.76	–314.65	314.32	0.33
		Tugu	3,010.77	2,649.19	189.21	172.38	2,581.48	202.33	226.97	–98.28	43.69	54.59
2	Semarang Regency	Bawen	4,693.01	3,895.16	726.78	71.07	3,880.83	730.43	81.76	–117.51	106.82	10.68
		Bergas	4,532.71	3,546.26	861.01	125.44	3,519.40	864.77	148.55	–128.49	105.39	23.10
		Kaliwungu	3,202.81	2,174.31	1,028.50	–	2,170.61	1,032.20	–	–62.09	62,09	0.00
		Pabelan	5,056.68	4,247.06	807.97	1.65	4,193.45	861.23	2.01	–33.19	32.83	0.36
		Pringapus	8,340.39	7,760.92	544.03	35.44	7,739.63	548.63	52.13	–94.94	78.24	16.70
		Suruh	6,562.95	5,267.09	1,295.86	–	5,259.98	1,302.96	–	–30.28	30.28	0.00
		Susukan	4,916.81	3,430.83	1,485.98	–	3,423.58	1,493.22	–	–42.22	42.22	0.00
		Tengaran	4,978.14	3,532.17	1,414.86	31.11	3,513.52	1,424.55	40.07	–54.85	45.89	8.96
		Tuntang	5,031.86	4,012.64	1,017.51	1.71	4,002.33	1,027.82	1.71	–25.15	25.15	0.00
		Ungaran Barat	4,993.95	4,010.63	965.27	18.05	4,005.80	970.10	18.05	–152.18	152.18	0.00
		Ungaran Timur	6,163.05	5,189.28	919.52	54.25	5,185.60	921.68	55.77	–121.75	120.23	1.52

Source: Own Analysis, based on the satellite images analysis (Landsat5 and Google Earth)

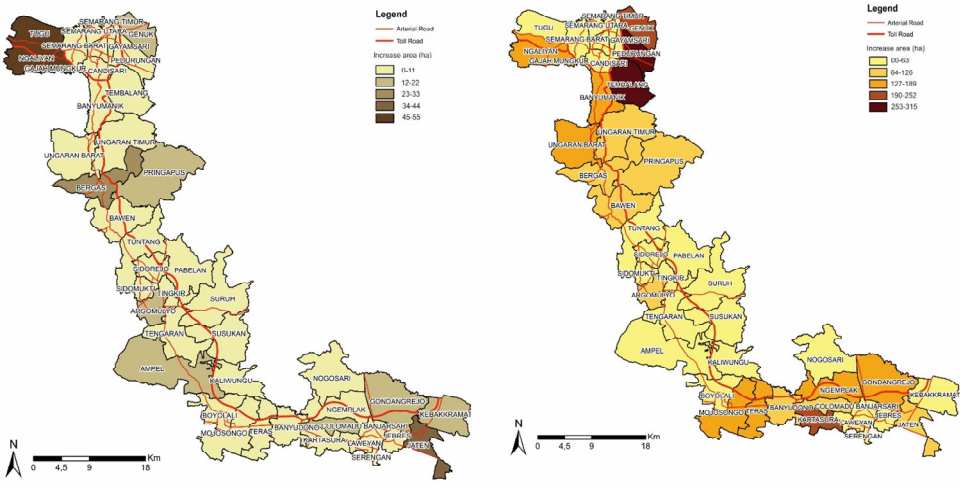
Table 4 Land-use change by sub-district (2008–2018) (continued)

	City/regency	Sub-districts (Kecamatan)	Area (Ha)	Land-use 2008 (Ha)			Land-use 2018 (Ha)			Land-use change 2008–2018 (Ha)		
				Unbuilt-up	Non-industrial built-up	Industry	Unbuilt-up	Non-industrial built-up	Industry	Unbuilt-up	Non-industrial built-up	Industry
3	Salatiga City	Argomulyo	1,929.54	1,068.32	802.26	58.96	1,053.73	802.26	73.55	–127.02	112.43	14.59
		Sidomukti	1,130.18	540.08	584.99	5.11	539.27	585.32	5.59	–20.97	20.49	0.48
		Sidorejo	1,726.95	997.38	723.07	6.50	997.38	723.07	6.50	–19.80	19.80	0.00
		Tingkir	999.35	474.90	522.21	2.24	474.36	522.75	2.24	–40.12	40.12	0.00
4	Boyolali Regency	Ampel	9,373.44	7,218.36	2,134.28	20.80	7,162.87	2,172.39	38.18	–76.60	59.23	17.37
		Banyudono	2,749.65	1,782.49	919.71	47.45	1,770.61	928.72	50.32	–93.68	90.80	2.87
		Boyolali	3,094.47	1,459.43	1,625.68	9.36	1,440.32	1,641.85	12.30	–37.31	34.37	2.94
		Mojosongo	4,518.94	2,916.41	1,567.05	35.49	2,883.88	1,593.90	41.16	–177.91	172.24	5.67
		Ngemplak	3,979.58	2,283.15	1,689.31	7.12	2,232.11	1,738.51	8.96	–128.37	126.53	1.84
		Nogosari	5,528.53	3,510.49	2,014.69	3.35	3,486.17	2,036.97	5.40	–44.12	42.08	2.04
		Teras	3,020.40	1,988.50	996.21	35.70	1,949.96	1,027.58	42.86	–179.26	172.1,0	7.16
5	Karanganyar Regency	Colomadu	1,775.41	850.07	898.85	26.48	828.59	905.56	41.26	–127.50	112.72	14.78
		Gondangrejo	6,129.09	4,582.52	1,505.44	41.13	4,520.77	1,548.53	59.79	–206.80	187.44	19.35
		Jaten	2,687.03	1,761.80	720.68	204.56	1,689.15	768.05	229.83	–102.55	68.63	33.92
		Kebakkramat	3,984.42	3,023.23	871.45	89.75	2,990.18	891.64	102.61	–76.99	61.47	15.53
6	Surakarta City	Banjarsari	1,584.55	263.34	1,301.59	19.62	230,27	1,333.75	20,53	–33.07	32.16	0.91
		Jebres	1,374.32	325.82	1,036.27	12.22	263,13	1,096.91	14,29	–62.70	60.63	2.07
		Laweyan	966.61	102.78	843.32	20,51	74,24	870,240	22,129	–28.54	26.93	1.61
		Serengan	307.16	10.32	292.47	4,37	9,17	293,620	4,37	–1.14	1.14	0.00
7	Sukoharjo Regency	Kartasura	2,101.82	819.40	1,220.70	61.72	692.27	1,338.34	71.21	–208.80	199.31	9.49
Total			*144,120.63*	*97,196.69*	*44,523.48*	*2,400.41*	*96,153.68*	*45,244.28*	*2,722.63*	*2,172.39*	*38.18*	*345.32*

Source: Own Analysis, based on the satellite images analysis (Landsat5 and Google Earth)

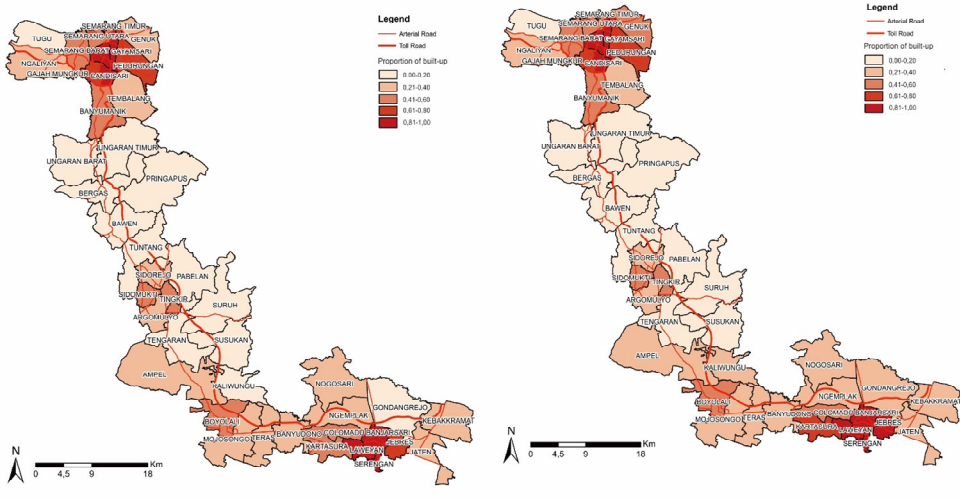
As noted, the proportion of built-up area is a measure of urbanisation, and Figure 4 shows that this proportion in the total area by sub-district in 2008 and 2018 retained the same pattern. A significant increase occurred only in the Gondangrejo sub-district, which in 2018 became like its surrounding districts.

Figure 3 (a) Increase in industrial and (b) built-up areas between 2008–2018 (see online version for colours)



(a) (b)

Figure 4 Built-up area as a proportion of the total, by sub-district in 2008 and 2018 (see online version for colours)



The other indicator used to measure the urbanisation level is population density, as shown in Figure 5 by sub-district in 2008 and 2018. This spatial pattern was quite similar to the proportion of built-up area in the total population. Moreover, a significant increase in

population density occurred in three sub-districts of Semarang Regency, namely Ungaran Barat, Ungaran Timur, and Bergas, and one sub-district of Semarang City, namely Ngaliyan.

Figure 5 Population density by sub-district in 2008 and 2018 (see online version for colours)

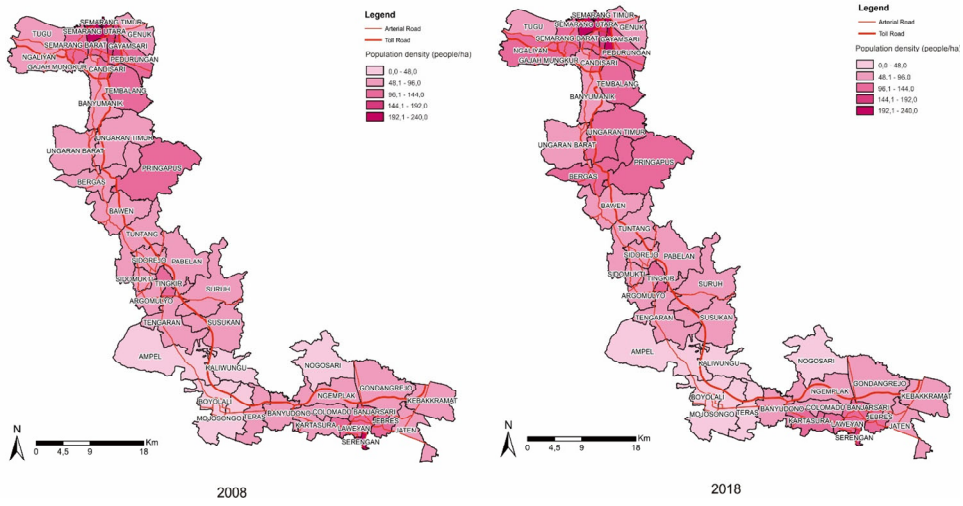


Figure 6 KDA 2008 and 2018 (see online version for colours)

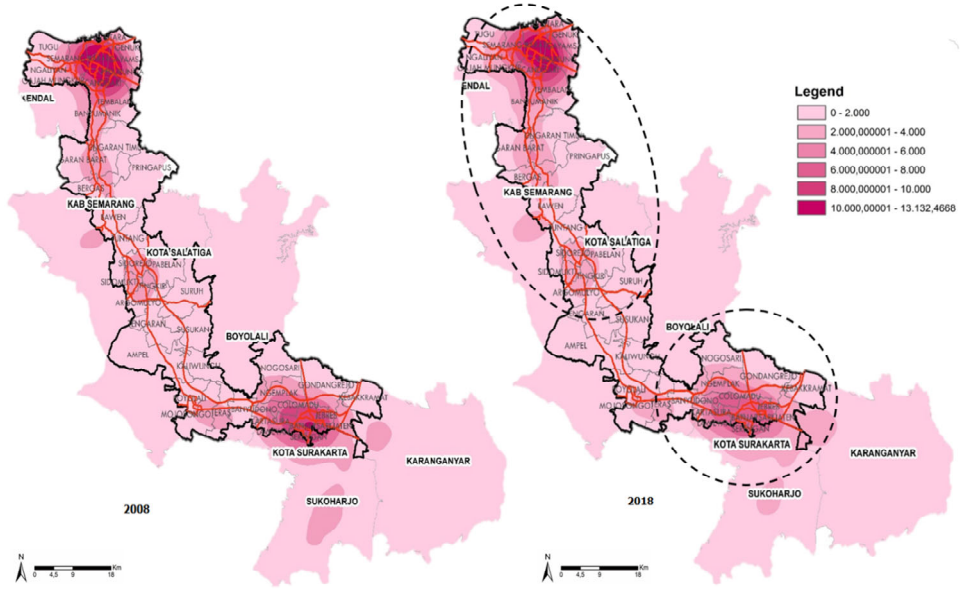
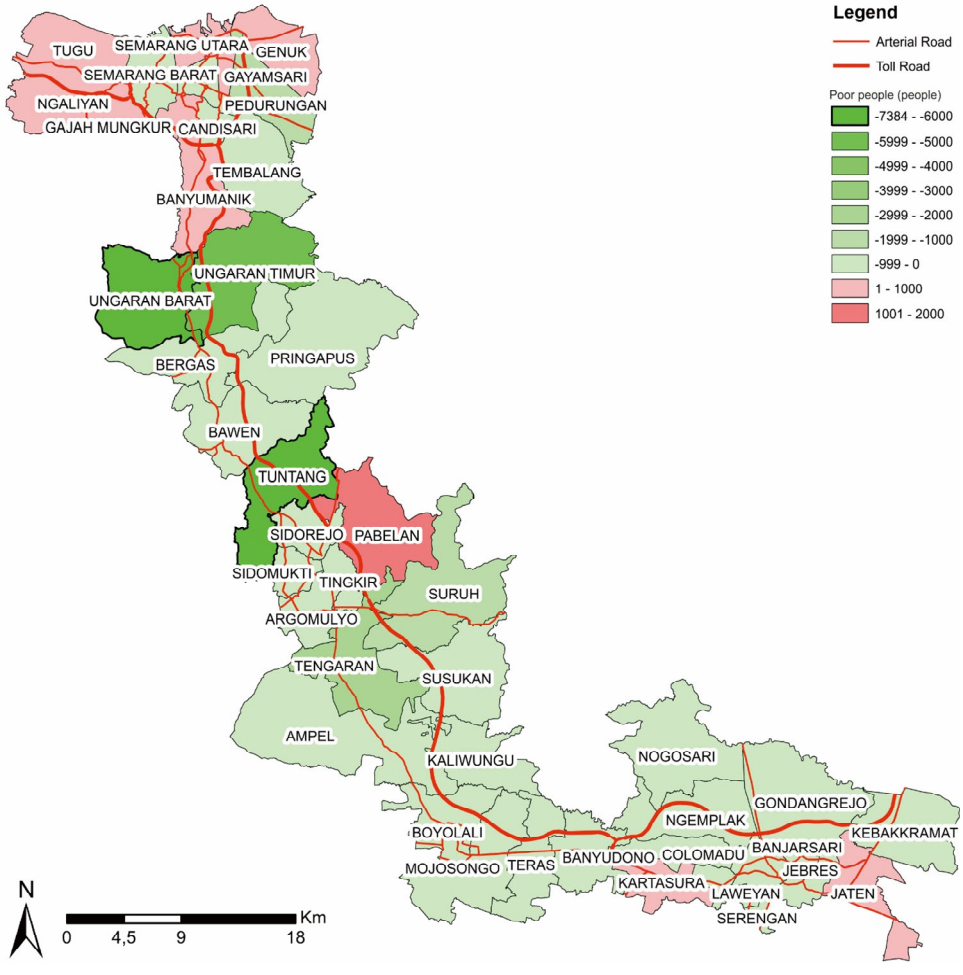


Figure 6 shows the result of KDA based on population per district between 2008–2018. The map indicates that the darker the color, the higher the population density. There were two kernels of population density, located in the northern and southern parts of the study area. In the northern part, the kernel was concentrated in Semarang City, while the

southern part was centred in Surakarta City. In between these two kernels, there were four sub-kernels along the corridor located in the cities of Ungaran, Ambarawa, Salatiga, and Boyolali. This pattern remained relatively the same between 2008–2018, except in terms of the intensity of density.

The development in the northern part tended to widen the same kernel, extending in the southern direction connected with the sub-kernel in Ungaran City. The growth in the southern part was unique because there was a reduction in population density in the kernel area. The development extended in the southern and western directions, and even crossed the boundary of the study area. This indicates that the development of the areas surrounding the city of Surakarta was so very rapid that the population density in these areas increased.

Figure 7 Annual increase in poor persons by sub-district (see online version for colours)



The socio-economic indicator obtained during the survey was the number of poor persons by sub-district. Because the date of the data varies for each sub-district, the increase in the number of poor persons per year by sub-district was mapped, as shown in Figure 7. In

the study area, most sub-districts experienced a decline in the poor, but some, namely Tugu, Ngliyan, and Jaten, experienced an increase; this occurred in the sub-districts where industrial activity has been ongoing for a long time. The intensity of industrial activities has been attracting migrants to work as industrial labourers, but unfortunately limited income has increased the number of poor persons in these sub-districts. However, Pabelan (Semarang Regency) was an exception. It experienced an increase in the poor although its industrial activities were just developed. Unfortunately, the compiled data has not been able to explain why the poor increased there. Further investigation is therefore needed to clarify this point.

To observe the spatial dynamics of the sub-districts affected by the rise in industrial activities, Table 5 shows the proportion of built-up area to the total area, and the population density of the ten largest sub-districts with the highest increase in industrial area. It reveals that these were concentrated in four locations, namely one place in the north and south sides, and two in the middle. The four sub-districts in the south were double those in the north, and the four sub-districts in the middle indicates how the improvement of accessibility has driven industrial development in the middle of Central Java Province. The massive development in industrial areas has thus far occurred in the North Coast Area (Pantai Utara/Pantura) of Java, in which Semarang is the hub of the two most important growth centres in Java, namely Jakarta and Surabaya. The table also shows that all sub-districts experienced an increase in both population density and percent of built-up area. Although most of the sub-districts were still rural, this fact indicates that urbanisation is occurring there.

Table 5 The proportion of built-up area and population density

No.	*Sub-district*	*Regency/city*	*Population density (people/Ha)*		*Percent of built-up area*	
			2008	*2018*	*2008*	*2018*
1	Tugu	Semarang City	9.0	11.6	11%	14%
2	Ngaliyan	Semarang City	24.6	31.2	28%	32%
3	Jaten	Karanganyar Regency	25.8	31.3	36%	40%
4	Bergas	Semarang Regency	12.9	18.8	16%	18%
5	Godangrejo	Karanganyar Regency	10.8	13.0	19%	22%
6	Ampel	Boyolali Regency	7.3	8.4	21%	22%
7	Pringapus	Semarang Regency	6.0	6.9	5%	6%
8	Kebakkramat	Karanganyar Regency	14.7	15.8	21%	23%
9	Colomadu	Karanganyar Regency	32.2	45.5	42%	49%
10	Argomulyo	Salatiga City	21.5	23.2	27%	34%

Source: Own computation, based on the results of satellite images analysis and the Statistic Office's data

Table 6 shows the change in the percent of urban employment and number of poor persons in the ten largest sub-districts with the highest increase in the industrial area. It reveals that most sub-districts experienced an increase in the percent of urban employment, except for the Ampel sub-district, and a slight decrease in the number of poor persons, except for the three sub-districts of Tugu, Ngaliyan, and Jaten.

The sub-districts experiencing a slight increase in the number of poor persons were the sub-districts where industrial activities have been ongoing for a long time. On the contrary, the sub-districts experiencing a slight decrease were those in which industrial activities have begun more recently. Regarding the percent of urban employment as an indicator of urbanisation, it is clear that urbanisation has occurred in all sub-districts. However, the decline in the percent of urban employment in the Ampel sub-district requires further investigation to determine what has happened there.

Table 6 The change of percent of urban employment and poor persons

No.	*Sub-district*	*Regency/city*	*Percent of urban employment*		*Number of poor persons*	
1	Tugu	Semarang City	(2008) 82%	(2010) 83%	(2008) 0	(2018) 803
2	Ngaliyan	Semarang City	(2008) 76%	(2010) 86%	(2008) 1,677	(2018) 2,199
3	Jaten	Karanganyar Regency	(2008) 92%	(2010) 93%	(2008) 1,486	(2018) 2,064
4	Bergas	Semarang Regency	(2005) 21%	(2018) 59%	(2008) 3,425	(2018) 2,991
5	Godangrejo	Karanganyar Regency	(2008) 77%	(2010) 77%	(2008) 6,637	(2018) 5,503
6	Ampel	Boyolali Regency	(2008) 57%	(2015) 52%	(2008) 9,781	(2018) 5,611
7	Pringapus	Semarang Regency	(2005) 28%	(2018) 49%	(2008) 5,438	(2018) 4,895
8	Kebakkramat	Karanganyar Regency	(2008) 75%	(2010) 75%	(2008) 3,613	(2018) 1,668
9	Colomadu	Karanganyar Regency	(2008) 94%	(2010) 95%	(2008) 1,209	(2018) 900
10	Argomulyo	Salatiga City	(2008) 59%	(2015) 79%	(2007) 1,798	(2015) 456

Source: Own computation, based on the Statistic Office's data

5 Discussion

Accessibility is one factor driving urbanisation, especially in attracting people to the region (Liu et al., 2014; Feng et al., 2019). The results of this study show that not all the sub-districts passed by the toll road in the study area experienced significant change, either in terms of physical or non-physical aspects. The encroachment of non-industrial built-up and industrial areas in each sub-district varied. Moreover, several sub-districts in the south of the study area experienced a decline in population density, indicating that the construction of the toll road was not the only driving factor of urbanisation in the sub-districts passed by the toll road. This result is in line with Ma et al. (2018) and Hu et al. (2017), who found that the characteristics of every region influence the development of the industrial activities there.

The study area corridor connects two young metropolises, the Semarang Metropolitan Area (SMA) in the north and the Solo Raya Metropolitan (SRM) in the south. The urban development occurring at both ends of the corridor represents the concept of desakota in urban expansion, as stated by McGee (1991). This development was marked by an increase in population density, mobility, and interaction with the parent city, the emergence of urban activities, and an increase in mixed land use regarding rural and urban functions. Between the two ends of the corridor, the three cities of Salatiga, Boyolali (the capital of Boyolali Regency), and Ungaran (the capital of Semarang Regency) have developed, alongside the strong interaction between Semarang and Surakarta. Of these, Salatiga City developed the fastest.

Previous study of Firman (2009) showed that large-scale housing and new town, infrastructure and industrial estate development were the main driving factor of development in the corridor of Jakarta-Bandung. In the study area, they were almost the same, except for the scale level. The large scale of housing has not yet appeared massively, nor has the new town. However, small-scale residential areas have emerged scattered along the corridor. Industrial activities were still concentrated around the two main cities, although one or two factories have begun to appear in several locations along the corridor. In the areas with good accessibility, that was, areas around toll gates, settlements grew faster. Infrastructure and industrial estate development were not yet visible but the sign in that direction has begun to emerge.

The development of built-up areas tended to follow the regional line of either the arterial or toll road connecting Semarang and Surakarta. This is in line with other studies (McGee, 1991; Lizhu et al., 2013; Shi and Cao, 2019) on the emergence of mixed-use urban and rural lands along a transportation route. In the outer city areas of this study area, industrial activities were scattered along the arterial road or around the exit gates of the toll road, while increasing residential areas were gathered in areas that had initially been traditional settlements or extensions of existing urban settlements.

Industrial development can accelerate the regional economy (Murphy, 2007; Ma et al., 2018). In the study area, even though economic development was uneven in every sub-district, the variable increase in population and built-up areas where industrial activities also increased confirms this statement. Unfortunately, the data on regional domestic product by sub-district could not be obtained during the survey. Thus, the question of whether the development of industrial activities has increased the economy of the sub-districts cannot be answered with certainty. However, the fact that both the built-up and industrial areas along the corridor have grown confirms that the road network accelerated the development of this region. In this case, the road network acted as the veins in the system of urban and regional development, in line with the findings of Yudhistira et al. (2019) and Luo et al. (2018).

Another interesting fact was the slight increase or decrease in the number of poor persons in those sub-districts experiencing significant growth in industrial areas. For the sub-districts which had more established industrial activity, there was a slight increase in poor persons, while those sub-districts with less developed activity experienced a slight decrease. These facts indicate that, at the beginning of their development, the industrial activities improved the incomes of the local people, but unfortunately this improvement did not last. Depending on certain factors, in some cases the development of industrial activities even increased the number of poor persons. This raises important questions about the sustainability of future industrial development. For this reason, appropriate

strategies for industrial development are necessary for local governments to avoid any adverse effects of the industrial activities.

Field observations conducted in 2019 revealed that the toll road has improved the accessibility of the region, and this improvement has affected the development of the urban activities in the study area. All the sub-districts experienced an increase in built-up area as a proportion of the total area. Some urban sub-districts, in both the metropolitan areas and the capital cities of the regencies, experienced an increase in industrial area. In this context, the road network has directed urban development, in line with studies by Fahmi et al. (2016) and Yudhistira et al. (2019) regarding the relationship between accessibility and urbanisation. The toll road acted as a magnet for urban growth and development in this region.

The field observations also showed that various urban activities like settlement, trade, services, and industry have begun to develop around the toll gates, but unfortunately this development is insignificant because the toll road has only been operating for a year. As preliminary evidence, this fact supports the findings of Duran-Fernandez and Santos (2014), who found that transport infrastructures such as toll roads, highways, and railways can stimulate economic development. However, whether this advantage also potentially increases the welfare level of the region needs further verification. The preliminary evidence also shows that industrial development in a sub-district does not always directly reduce the number of poor persons in a sub-district.

6 Conclusions

This study has successfully observed the spatial dynamics of a development corridor affected by the change of regional transport infrastructure. It reveals that accessibility can accelerate regional development and urbanisation. In the areas where accessibility increases, for example those near the exit and entrance of toll roads, industrial development can occur. They may develop faster than others. However, it does not always improve the welfare of the population in the long-term. At the beginning, it may have a direct impact on the income of the local population, but in line with the growth of migrant workers who may not get adequate income, the number of poor persons can also increase.

In the case of the corridor connecting Semarang and Surakarta, two young metropolitans, the empirical findings of this study largely confirm the results of previous studies. The driving factors were in line with those in the corridor connecting Jakarta-Bandung, except for the scale level. However, there were some interesting notes, one of which is the fact that infrastructure development was not the only factor driving urbanisation. Many other factors also determined the process of urbanisation and regional development in the study area, and these are mostly related to regional characteristics. Another interesting note is that the development pattern in the study area generally followed the regional lines of both the arterial road, which has existed for a long time, and the toll road, which has been operating for about a year. In general, the sub-districts through which the regional lines pass experienced significant developments. As for industrial activities, these usually developed in the sub-districts in which the toll gate is located, indicating that the toll road is functioning as a magnet for industrial development in this region.

Furthermore, an increase in industrial activities was not always followed by an increase in incomes, as indicated by an increase in the numbers of poor persons. Indeed, some sub-districts which had well established industrial activities experienced an increase in the number of poor persons; in contrast, where there was a decline in the number of poor persons, the industrial activities were relatively new. This empirical finding requires special attention from local governments, especially in terms of establishing regional policies to guarantee sustainable positive impacts from the development of industrial activities.

The development of the areas around the corridor identified with an economic growth has a significant impact in spatial. If the policy is just directed at improving the economic quality, the growth will agglomerate on the areas around the corridor. An appropriate policy is therefore necessary to maintain the balance of the land use patterns. Finally, this study has important implications for how the strategies of transportation infrastructure and regional development should be synergised.

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References

Aguilar, A.G., Ward, P.M. and Smith Sr., C. (2003) 'Globalization, regional development, and mega-city expansion in Latin America: analyzing Mexico City's peri-urban hinterland', *Cities*, Vol. 20, No. 1, pp.3–21, DOI: 10.1016/S0264-2751(02)00092-6.

Allen, A. (2003) 'Environmental planning and management of the peri-urban interface: perspectives on an emerging field', *Environment and Urbanization*, Vol. 15, No. 1, pp.135–148, DOI: 10.1177/095624780301500103.

Al-Sharif, A.A.A. and Pradhan, B. (2016) 'Spatio-temporal prediction of urban expansion using bivariate statistical models: assessment of the efficacy of evidential belief functions and frequency ratio models', *Applied Spatial Analysis and Policy*, Vol. 9, No. 2, pp.213–231, DOI: 10.1007/s12061-015-9147-1.

Athukorala, P. and Narayanan, S. (2018) 'Economic corridors and regional development: the Malaysian experience', *World Development*, Vol. 106, pp.1–14, Elsevier Ltd., DOI: 10.1016/j.worlddev.2018.01.009.

Banzhaf, E. et al. (2013) 'Do demographic and land-use changes contrast urban and suburban dynamics? A sophisticated reflection on Santiago de Chile', *Habitat International*, Vol. 39, pp.179–191, Elsevier Ltd., DOI: 10.1016/j.habitatint.2012.11.005.

Berdegué, J.A. et al. (2015) 'Cities, territories, and inclusive growth: unraveling urban-rural linkages in Chile, Colombia, and Mexico', *World Development*, Vol. 73, pp.56–71, DOI: 10.1016/j.worlddev.2014.12.013.

Buchori, I. et al. (2017) 'Theorizing spatial dynamics of metropolitan regions: a preliminary study in Java and Madura Islands, Indonesia', *Sustainable Cities and Society*, August, Vol. 35, pp.468–482, Elsevier, DOI: 10.1016/j.scs.2017.08.022.

Buchori, I. et al. (2018) 'The influence of sprawl development, income, and infrastructure on energy consumption in Central Java Province, Indonesia', *Geoplanning: Journal of Geomatics and Planning*, Vol. 5, No. 2, p.189, DOI: 10.14710/geoplanning.5.2.189-204.

Buchori, I. et al. (2020) 'Urban expansion and welfare change in a medium-sized suburban city: Surakarta, Indonesia', *Environment and Urbanization ASIA*, Vol. 11, No. 1, pp.78–101, DOI: 10.1177/0975425320909922.

Budiyantini, Y. and Pratiwi, V. (2016) 'Peri-urban typology of Bandung Metropolitan Area', *Procedia – Social and Behavioral Sciences*, November 2015, Vol. 227, pp.833–837, Elsevier B.V., DOI: 10.1016/j.sbspro.2016.06.152.

Caragliu, A. and Del Bo, C.F. (2019) 'Smart innovative cities: the impact of smart city policies on urban innovation', *Technological Forecasting and Social Change*, May 2018, Vol. 142, pp.373–383, Elsevier, DOI: 10.1016/j.techfore.2018.07.022.

Chen, C. and Zhao, M. (2017) 'The undermining of rural labor out-migration by household strategies in China's migrant-sending areas: the case of Nanyang, Henan Province', *Cities*. Vol. 60, pp.446–453, Elsevier B.V., DOI: 10.1016/j.cities.2016.04.009.

Dadashpoor, H., Azizi, P. and Moghadasi, M. (2019) 'Analyzing spatial patterns, driving forces and predicting future growth scenarios for supporting sustainable urban growth: evidence from Tabriz metropolitan area, Iran', *Sustainable Cities and Society*, Vol. 47, p.101502, DOI: 10.1016/j.scs.2019.101502.

Duran-Fernandez, R. and Santos, G. (2014) 'Road infrastructure spillovers on the manufacturing sector in Mexico', *Research in Transportation Economics*, Vol. 46, pp.17–29, Elsevier Ltd., DOI: 10.1016/j.retrec.2014.09.002.

Duvernoy, I. et al. (2018) 'Pictures from the other side of the fringe: urban growth and peri-urban agriculture in a post-industrial city (Toulouse, France)', *Journal of Rural Studies*, September 2017, Vol. 57, pp.25–35, Elsevier, DOI: 10.1016/j.jrurstud.2017.10.007.

Dwyer, M.B. (2020) ''They will not automatically benefit': the politics of infrastructure development in Laos's Northern Economic Corridor', *Political Geography*, December 2019, Vol. 78, Elsevier Ltd., DOI: 10.1016/j.polgeo.2019.102118.

Fahmi, F.Z. et al. (2016) 'Leadership and collaborative planning: the case of Surakarta, Indonesia', *Planning Theory*, Vol. 15, No. 3, pp.294–315, DOI: 10.1177/1473095215584655.

Feng, W., Liu, Y. and Qu, L. (2019) 'Effect of land-centered urbanization on rural development: a regional analysis in China', *Land Use Policy*, Vol. 87, DOI: 10.1016/j.landusepol.2019.104072.

Firman, T. (2009) 'The continuity and change in mega-urbanization in Indonesia: a survey of Jakarta-Bandung Region (JBR) development', *Habitat International*, Vol. 33, No. 4, pp.327–339, Elsevier Ltd., DOI: 10.1016/j.habitatint.2008.08.005.

Firman, T. and Fahmi, F.Z. (2017) 'The privatization of Metropolitan Jakarta's (Jabodetabek) urban fringes: the early stages of 'post-suburbanization' in Indonesia', *Journal of the American Planning Association*, Vol. 83, No. 1, pp.68–79, DOI: 10.1080/01944363.2016.1249010.

Garcia-López, M-À. (2012) 'Urban spatial structure, suburbanization and transportation in Barcelona', *Journal of Urban Economics*, Vol. 72, Nos. 2–3, pp.176–190, DOI: 10.1016/j.jue.2012.05.003.

Guo, Y., Zhu, J. and Liu, X. (2018) 'Implication of rural urbanization with place-based entitlement for social inequality in China', *Cities*, November 2017, Vol. 82, pp.77–85, Elsevier, DOI: 10.1016/j.cities.2018.05.007.

Hall, P. (2002) *Urban and Regional Planning*, Routledge, New York.

Han, X., Wu, P.L. and Dong, W.L. (2012) 'An analysis on interaction mechanism of urbanization and industrial structure evolution in Shandong, China', *Procedia Environmental Sciences*, Vol. 13, No. 2011, pp.1291–1300, DOI: 10.1016/j.proenv.2012.01.122.

Hart, K. (2018) 'The suburbanization of rural life in an arid and rocky village in western Turkey', *Journal of Arid Environments*, Vol. 149, pp.73–79, Elsevier Ltd., DOI: 10.1016/j.jaridenv.2017.03.011.

Hu, F. et al. (2017) 'Hierarchy in industrial structure: the cases of China and the USA', *Physica A: Statistical Mechanics and its Applications*, Vol. 469, pp.871–882, Elsevier B.V., DOI: 10.1016/j.physa.2016.11.083.

Hudalah, D. et al. (2013) 'Industrial land development and manufacturing deconcentration in Greater Jakarta', *Urban Geography*, Vol. 34, No. 7, pp.950–971, DOI: 10.1080/02723638.2013.783281.

Hudalah, D. et al. (2019) 'Connecting fragmented enclaves through network? Managing industrial parks in the Jakarta-Bandung Urban Corridor', *Cities*, November 2018, Vol. 88, pp.1–9, Elsevier, DOI: 10.1016/j.cities.2019.01.005.

Hudalah, D., Firman, T. and Woltjer, J. (2014) 'Cultural cooperation, institution building and metropolitan governance in decentralizing Indonesia', *International Journal of Urban and Regional Research*, Vol. 38, No. 6, pp.2217–2234, DOI: 10.1111/1468-2427.12096.

Inouye, C.E.N. et al. (2015) 'Modelling the spatial dynamics of urban growth and land use changes in the north coast of São Paulo, Brazil', *Ocean & Coastal Management*, Vol. 108, pp.147–157, DOI: 10.1016/j.ocecoaman.2014.12.016.

Komlos, J. and A'Hearn, B. (2017) 'Hidden negative aspects of industrialization at the onset of modern economic growth in the U.S.', *Structural Change and Economic Dynamics*, Vol. 41, pp.43–52, Elsevier B.V., DOI: 10.1016/j.strueco.2017.03.001.

Legates, R. and Hudalah, D. (2014) 'Peri-urban planning for developing East Asia: learning from Chengdu, China and Yogyakarta/Kartamantul, Indonesia', *Journal of Urban Affairs*, Vol. 36, Sup. 1, pp.334–353, DOI: 10.1111/juaf.12106.

Li, X. et al. (2019) 'Towards sustainable smart cities: an empirical comparative assessment and development pattern optimization in China', *Journal of Cleaner Production*, Vol. 215, pp.730–743, Elsevier Ltd., DOI: 10.1016/j.jclepro.2019.01.046.

Liu, S., Zhang, P. and Lo, K. (2014) 'Urbanization in remote areas: a case study of the Heilongjiang Reclamation Area, Northeast China', *Habitat International*, Vol. 42, pp.103–110, Elsevier Ltd., DOI: 10.1016/j.habitatint.2013.11.003.

Liu, Z. et al. (2018) 'Urban sprawl among Chinese cities of different population sizes', *Habitat International*, May 2017, Vol. 79, pp.89–98, Elsevier, DOI: 10.1016/j.habitatint.2018.08.001.

Lizhu, D., Fung-shuen, S.V. and Yanting, Z. (2013) 'Formation and delimitation of Extended Metropolitan Regions (EMRS) in Central China: a case study in the Changzhutan EMR', *International Journal of Humanities and Social Science*, Vol. 3, No. 12, pp.265–277.

Long, C. and Zhang, X. (2012) 'Patterns of China's industrialization: concentration, specialization, and clustering', *China Economic Review*, Vol. 23, No. 3, pp.593–612, Elsevier Inc., DOI: 10.1016/j.chieco.2011.09.002.

Long, H., Zou, J. and Liu, Y. (2009) 'Differentiation of rural development driven by industrialization and urbanization in eastern coastal China', *Habitat International*, Vol. 33, No. 4, pp.454–462, Elsevier Ltd., DOI: 10.1016/j.habitatint.2009.03.003.

Luo, Z. et al. (2018) 'Urban pollution and road infrastructure: a case study of China', *China Economic Review*, August 2016, Vol. 49, pp.171–183, Elsevier, DOI: 10.1016/j.chieco.2017.04.008.

Ma, W. et al. (2018) 'Rural settlements transition (RST) in a suburban area of metropolis: internal structure perspectives', *Science of The Total Environment*, Vol. 615, No. 19, pp.672–680, Elsevier B.V., DOI: 10.1016/j.scitotenv.2017.09.152.

McGee, T.G. (1971) *The Urbanization Process in the Third World*, G. Bell and Sons, Ltd., London.

McGee, T.G. (1991) 'The emergence of Desakota regions in Asia: expanding a hypothesis', in Ginsberg, N., Koppel, B., and McGee, T.G. (Eds.): *The Extended Metropolis: Settlement Transition in Asia*, pp.3–26, University of Hawaii Press, Honolulu.

Murphy, J.T. (2007) 'The challenge of upgrading in African industries: socio-spatial factors and the urban environment in Mwanza, Tanzania', *World Development*, Vol. 35, No. 10, pp.1754–1778, DOI: 10.1016/j.worlddev.2007.06.003.

Octifanny, Y. and Hudalah, D. (2017) 'Urban agglomeration and extension in Northern Coast of West Java: a transformation into Mega Region', *IOP Conference Series: Earth and Environmental Science*, Vol. 79, DOI: 10.1088/1755-1315/79/1/012011.

Pontifex, D. and Silitonga, Y. (2010) 'Tahapan Perkembangan Metropolitan Jabodetabek Berdasarkan Perubahan pada Aspek Lingkungan', *Journal of Regional and City Planning*, Vol. 21, No. 3, pp.197–214.

Rukmana, S.N. and Rudiarto, I. (2016) 'Land use change in suburban area: a case of Malang City, East Java Province', *Geoplanning: Journal of Geomatics and Planning*, Vol. 3, No. 1, pp.23–32, DOI: 10.14710/geoplanning.3.1.23-32.

Salvati, L., Sateriano, A. and Bajocco, S. (2013) 'To grow or to sprawl? Land cover relationships in a Mediterranean City Region and implications for land use management', *Cities*, Vol. 30, pp.113–121, Elsevier Ltd., DOI: 10.1016/j.cities.2012.01.007.

Setyono, J.S., Yunus, H.S. and Giyarsih, S.R. (2016) 'The spatial pattern of urbanization and small cities development in Central Java: a case study of Semarang-Yogyakarta-Surakarta Region', *Geoplanning: Journal of Geomatics and Planning*, Vol. 3, No. 1, pp.53–66, DOI: 10.14710/geoplanning.3.1.53-66.

Shang, J. et al. (2018) 'A study on the correlation between technology innovation and the new-type urbanization in Shaanxi province', *Technological Forecasting and Social Change*, Vol. 135, February 2017, pp.266–273, Elsevier, DOI: 10.1016/j.techfore.2018.04.029.

Shi, Q. and Cao, G. (2019) 'Urban spillover or rural industrialisation: which drives the growth of Beijing Metropolitan Area', *Cities*, September 2018, p.1, Elsevier, DOI: 10.1016/j.cities. 2019.05.023.

Sloan, S. et al. (2019) 'Hidden challenges for conservation and development along the trans-Papuan economic corridor', *Environmental Science & Policy*, October 2018, Vol. 92, pp.98–106, Elsevier, DOI: 10.1016/j.envsci.2018.11.011.

Soh, M.B.C. (2012) 'Crime and urbanization: revisited Malaysian case', *Procedia – Social and Behavioral Sciences*, July 2010, Vol. 42, pp.291–299, DOI: 10.1016/j.sbspro.2012.04.193.

Song, H., Thisse, J-F. and Zhu, X. (2012) 'Urbanization and/or rural industrialization in China', *Regional Science and Urban Economics*, Vol. 42, Nos. 1–2, pp.126–134, Elsevier B.V., DOI: 10.1016/j.regsciurbeco.2011.08.003.

Sugiri, A., Buchori, I. and Ma'rif, S. (2015) 'Towards participatory spatial policy: facilitating rural non-farm activities in Susukan Suburb of Semarang Metropolitan Region', *The International Journal of Civic, Political, and Community Studies*, Vol. 13, No. 4, pp.1–17, DOI: 10.18848/ 2327-0047/CGP/v13i04/43588.

Taubenböck, H. et al. (2012) 'Monitoring urbanization in mega cities from space', *Remote Sensing of Environment*, Vol. 117, pp.162–176, Elsevier Inc., DOI: 10.1016/j.rse.2011.09.015.

United Nations, Department of Economic and Social Affairs, Population Division (2019) *World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420)*, United Nations, New York [online] https://esa.un.org/unpd/wup/Publications (accessed 7 October 2019).

Van Damme, O., Van Geelen, H. and Courange, P. (2016) 'The evaluation of road infrastructure development projects', *Transportation Research Procedia*, Vol. 14, pp.467–473, Elsevier B.V., DOI: 10.1016/j.trpro.2016.05.099.

Von Braun, J. (2007) 'Rural-urban linkages for growth, employment, and poverty reduction', in *Fifth International Conference on the Ethiopian Economy*, Addis Ababa: Ethiopian Economic Association, pp.1–21 [online] https://www.ifpri.org/cdmref/p15738coll5/id/1086/filename/ 1087.pdf (accessed 14 May 2019).

Walcott, S.M. and Pannell, C.W. (2006) 'Metropolitan spatial dynamics: Shanghai', *Habitat International*, Vol. 30, No. 2, pp.199–211, DOI: 10.1016/j.habitatint.2004.02.005.

Wang, B., Tian, L. and Yao, Z. (2018) 'Institutional uncertainty, fragmented urbanization and spatial lock-in of the peri-urban area of China: a case of industrial land redevelopment in Panyu', *Land Use Policy*, Vol. 72, pp.241–249, DOI: 10.1016/j.landusepol.2017.12.054.

Wijaya, H.B., Kurniawati, H. and Hutama, S.T.E.W. (2018) 'Industrialization impact on worker mobility and land use in peri urban area (case study of Semarang District, Indonesia)', *IOP Conference Series: Earth and Environmental Science*, Vol. 123, No. 1, DOI: 10.1088/1755-1315/123/1/012037.

Won, S., Cho, S.E. and Kim, S. (2015) 'The neighborhood effects of new road infrastructure: Transformation of urban settlements and resident's socioeconomic characteristics in Danang, Vietnam', *Habitat International*, Vol. 50, pp.169–179, Elsevier Ltd.,. DOI: 10.1016/j.habitatint.2015.08.037.

Xu, J. et al. (2019) 'How does city-cluster high-speed rail facilitate regional integration? Evidence from the Shanghai-Nanjing corridor', *Cities*, Vol. 85, November 2018, pp.83–97, Elsevier, DOI: 10.1016/j.cities.2018.12.003.

Yang, Y. et al. (2018) 'Measure of urban-rural transformation in Beijing-Tianjin-Hebei region in the new millennium: population-land-industry perspective', *Land Use Policy*, June, Vol. 79, pp.595–608, Elsevier, DOI: 10.1016/j.landusepol.2018.08.005.

Yudhistira, M.H. et al. (2019) 'Transportation network and changes in urban structure: evidence from the Jakarta Metropolitan Area', *Research in Transportation Economics*, August 2017, Vol. 74, pp.52–63, Elsevier, DOI: 10.1016/j.retrec.2018.12.003.

Zhang, R., Jiang, G. and Zhang, Q. (2019a) 'Does urbanization always lead to rural hollowing? Assessing the spatio-temporal variations in this relationship at the county level in China 2000–2015', *Journal of Cleaner Production*, Vol. 220, pp.9–22, Elsevier Ltd., DOI: 10.1016/j.jclepro.2019.02.148.

Zhang, X. et al. (2019b) 'Explaining the East Asia miracle: the role of urbanization', *Economic Systems*, December 2018, Elsevier, DOI: 10.1016/j.ecosys.2019.100697.

Zhang, X., Wan, G. and Wang, X. (2017) 'Road infrastructure and the share of labor income: evidence from China's manufacturing sector', *Economic Systems*, Vol. 41, No. 4, pp.513–523, Elsevier, DOI: 10.1016/j.ecosys.2017.08.001.

Zia, K. et al. (2013) 'An agent-based parallel geo-simulation of urban mobility during city-scale evacuation', *SIMULATION*, Vol. 89, No. 10, pp.1184–1214, DOI: 10.1177/0037549713485468.