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To cite this article: A B Ghazi *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **739** 012092

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Identification of changes in the morphological space structure of Bandar Lampung City using overlay geographic information system analysis

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Abstract. Cities are developing due to population growth, socio-economic structure changes, technology and spatial interaction with its surroundings. “Bagian Wilayah Kota (BWK) C” or so-called “urban zone C” of Bandar Lampung municipality comprising districts of Sukarama, Tanjung Senang, and Way Halim is currently growing both internally and externally due to the development of Trans-Sumatera highway and Institut Teknologi Sumatera (ITERA). The dynamics of development and activities have caused a growing physical urban space, affecting the changes of urban structure directly. The current development in BWK C has been considered as unmanageable and potentially caused some problems in spatial plan in the future. To prevent the chaotic of spatial plan in the future, this study aims to identify the changes of urban structure in BWK C of Bandar Lampung municipality due to the internal and external development of its area. This study benefits in providing comprehensive standpoints about the process of urban structure changes based on urban activities so that city government could gain a systematic discourse of urban development which advantages in policymaking for spatial development in Bandar Lampung municipality in the future. This study conducted several analytical methods ranging from comparative analysis, spatial analysis, and hierarchical centrality index analysis. For data collection, this study applied secondary data survey and field work observation, using data from 2010 to 2016. The findings of this study reveal that the physical development in BWK C is getting compacted as its morphology changed from ribbon shaped city to octopus shaped city.

1. Introduction

Cities are developing due to population growth, socio-economic structure changes, technology and spatial interaction with its surroundings. The city growth can be indicated by an increase of population number, the increase of buildings progressively, the larger built-up area mainly in settlement areas, and the increase of infrastructure construction that supports urban socio-economic activities [1]. It naturally happens when people meet and interact each other in order to meet their needs resulting many kinds of activities which are needed physical space supports. These ongoing activities have caused dynamics of physical space development, led to the changes of urban structure from time to time [2]. In the period between 2010 and 2016, Bandar Lampung municipalities had experienced some strategic development both at provincial and



national level. During that period, BWK C as a part of Bandar Lampung municipality experienced a strategic development at provincial and national level. According to the spatial plan of Bandar Lampung, BWK C area comprises several districts, including the district of Sukaramé, Tanjung Senang, and Way Halim. An indication of internal development in BWK C has been shown by the growing of economic activities, shown by the building of shopping center and the growing of commercial and services area both for formal or informal traders such as restaurants, café, home stay. Another indication is shown by infrastructure growth such as fly over, new route of public transport (Trans Lampung Bus), and an increasing of housing area and the development of Universitas Islam Negeri (UIN) Raden Intan in BWK C. Moreover, the external development near BWK C is the development of Institut Teknologi Sumatera (ITERA), a national highway development, a Public Hospital, and a new center of Kota Baru which is located in Jati Agung district. Regarding the internal and external development in BWK C, a study examining the changes of urban structure affected by those developments is significantly needed. Therefore, this study aims to identify the changes of urban structure in BWK C due to a rapid development. There are several objectives to achieve the goals comprised (1) Identification of population and economic growth in BWK C; (2) Identification of physical development in BWK C; and (3) Identification of structure changes in the morphological space in BWK C.

2. Methods

In terms of data processing, there are several stages conducted in this study. They are:

- 1) Map processing includes maps of administrative area, road networks, demography distribution, economic activity distribution, public facilities distribution, built-up and non-built-up areas, and also land use;
- 2) Data analyzing for demography and housing areas in order to examine the trend of population growth and its distribution with respect to the concentration of housing areas;
- 3) Data analyzing for land use mainly for economic purposes;
- 4) Map processing for determining the direction of development growth based on its spatial pattern. In this stage, an overlay technique is applied between a map of 2010 and a map of 2015 in order to show the spatial distribution for housing areas and built-up areas in BWK C.

This study applied comparative analysis and spatial analysis by using secondary data from 2010 to 2016 and fieldwork survey.

For the scope area, this study is focusing on BWK C which covers two district areas comprising district area of Sukaramé and Tanjung Senang and some areas of Way Halim district. Referring to spatial plan of Bandar Lampung 2011-2030, Way Halim district is a sub-urban center or known as “Sub-Pusat Pelayanan Kota (SPPK)” in Bahasa Indonesia. In a smaller scope area, BWK C has 13 sub-districts in which two sub-districts are in Way Halim district, six sub-districts are in Sukaramé district and the rest is in Tanjung Senang district. The area of BWK C is 2.847 Ha approximately which is divided into three areas including 1.475 Ha of Sukaramé, 1.163 Ha of Tanjung Senang and 209 Ha of Way Halim.

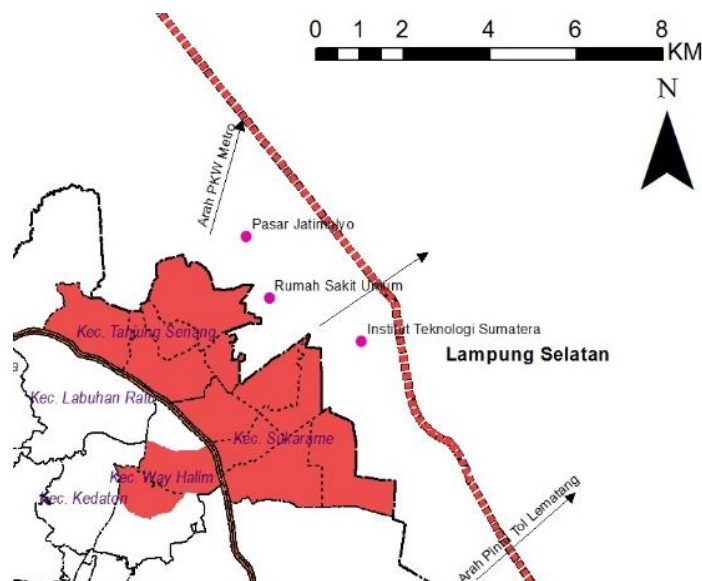


Figure 1. Study Area Map

3. Result and Discussion

Population growth is one of main indicators in urban development. According to this, the development of BWK C is significantly rapid as the population growth in this area has been increasing from time to time. Referring to the data from Statistics Bureau of Bandar Lampung, the population number of BWK C in 2010 was 111.977 and increased in 2015 around 124.345. In that sense, the population was increasingly growing approximately 11,05% within five years or increasing around 2,21% annually. Although the trend seemed like in positive trends, population growth in BWK was fluctuating during that period. In 2011, the growth was 1,09% from the total population in 2010. Thus, in 2012, the trend increased into 1,61% from 2011. Drastically, in 2013 the growth between 2012 and 2013 was jumping high around 4% while the next growth in 2014 was going down to 1,98%. In 2015, the growth was slightly decreasing into 1,92% and continued decreasing in 2016 into 1,90% (See Figure 2).

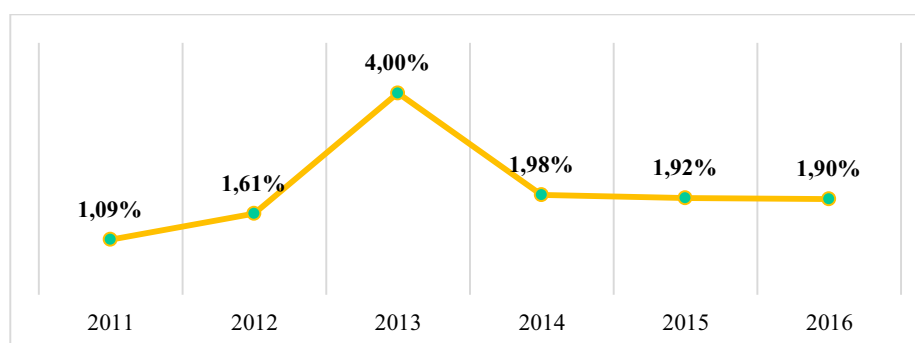


Figure 2. Population Growth Rate of BWK C Bandar Lampung City in 2010-2016

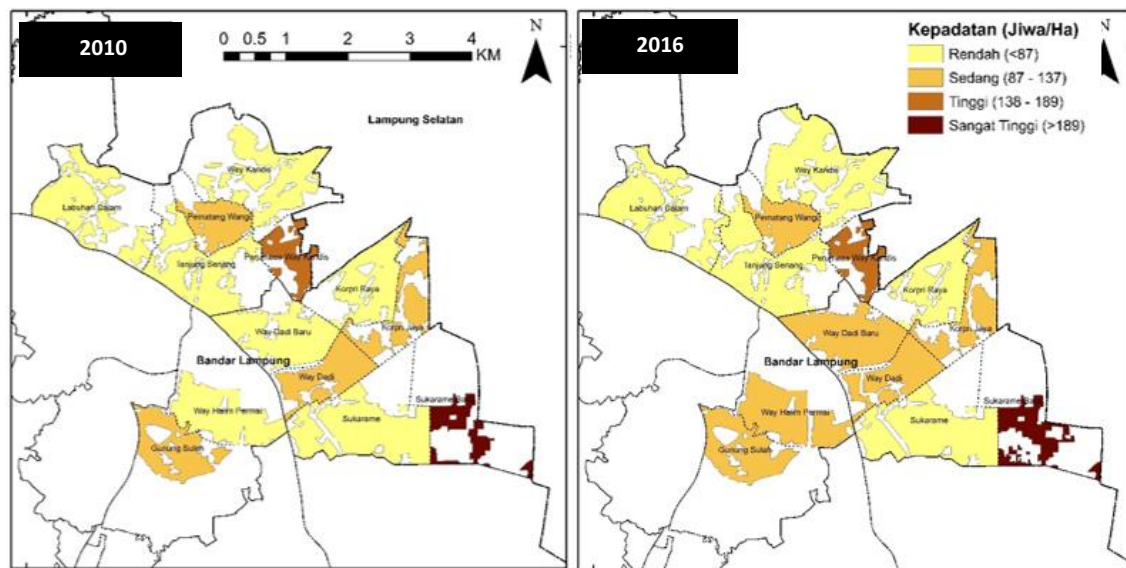


Figure 3. Population Density Map (Net)

According to Figure 3, the population density of BWK C in some housing areas was low in 2010 as it only had 87 people per hectare such as housing areas in sub-districts of Tanjung Senang, Way Kandis, Labuhan Dalam, Korpri Raya, Way Dadi Baru, Way Halim Permai and Sukarame. Meanwhile, some areas in BWK C had a medium population density comprising housing areas in sub-districts of Pematang Wangi, Way Dadi, Korpri Jaya, and Gunung Sulah. In 2010, there was Perumnas Way Kandis sub-district as a sole housing area which had a higher population density. Moreover, Sukarame sub-district had the highest population density in BWK C in that period which occupied by 240 people per hectare.

In 2016, there was a typological shift of population density in BWK C mainly in sub-districts of Way Dadi Baru and Way Halim Permai which transformed from low density area into medium density area with its density around 87 to 137 people per hectare. Regarding the land use in BWK C, the most growing activities in this area was commercial as the use of land for this activity had grown from 65,5 hectares in 2010 to 82 hectares in 2015 or around 25,2% (Figure 4).

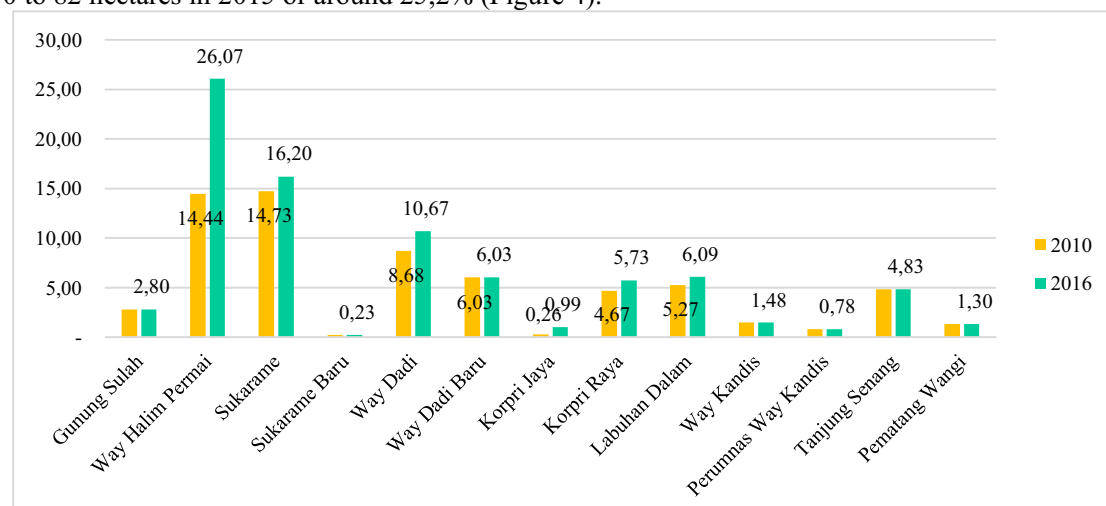


Figure 4. Area of Land Use for Trade and Services/Commercial per Sub-District in BWK C, 2010 and 2016

Referring to Figure 4, Way Halim Permai sub-district had been the most dominated by trade and services activities both for commercial in 2016 as its land use converted for commercial purposes had increased 14,44 hectares from 2010. The increase of economic activities in Way Halim Permai in 2016 was followed by Sukarama sub-district which had an increase of its land use around 14,73 hectares from 2010. According to Figure 5, it is shown that there was a shift of land use intensity for trade and services in BWK C as in 2010, Sukarama sub-district had the largest area for trade and services activities while in 2016, Way Halim Permai sub-district had become the largest area for trade and services activities in BWK C. In this case, Way Halim Permai sub-district had become the most growing area for economic activities in BWK C.

The distribution pattern of settlement land use has been widespread in all sub-districts of BWK C with the largest area was concentrated in Way Kandis sub-district. In 2016, the settlement area in Way Kandis had increased around 50 hectares from 2010. The settlement areas in this sub-district had increased due to the availability of land as it had a large of non-built-up areas, around 64% of total area Way Kandis sub-district, at that time. On the contrary, Sukarama sub-district as the second largest settlement area had not experienced any significant development in 2010 as this sub-district already had built-up areas around 84% of total area of Sukarama sub-district. However, the land use of Sukarama sub-district had been dominated by public facilities such as government offices like the office for Department of Public Work of Bandar Lampung and other facilities. Although the public facilities have been distributed in all areas of BWK C, the area of land use have not increased significantly in that period

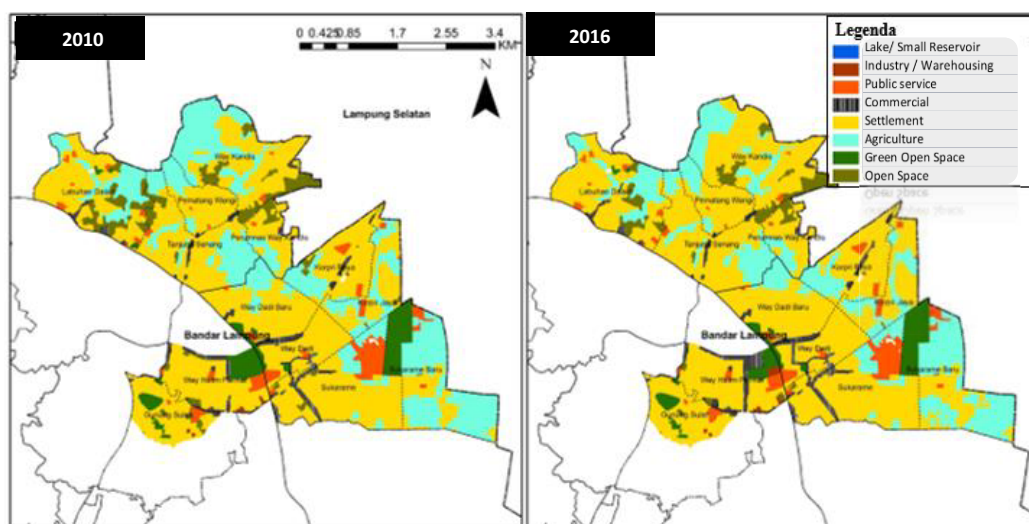


Figure 5. Land Use Distribution Map in 2010 and 2016 BWK C Bandar Lampung City

Table 1. Input-Output of Land Use in BWK C Bandar Lampung City in 2010 and 2016

2010 Land Use (Ha)	2016 Land Use (Ha)								Total Land Area 2010
	Lake/ Small Reservoir	Industry / Warehousing	Public service	Commercial	Settlement	Agriculture	Green Open Space	Open Space	
Small Reservoir/ Lake	2.64	-	-	-	-	-	-	-	2.64
Industry / Warehousing	-	2.98	-	-	-	-	-	-	2.98
Public service	0.10	-	85.12	-	-	-	-	-	85.23
Commercial	-	-	-	65.50	-	-	-	-	65.50
Settlement	-	-	-	6.53	1,302.75	-	-	1.34	1,310.61

2010 Land Use (Ha)	2016 Land Use (Ha)								Total Land Area 2010
	Lake/ Small Reservoir	Industry / Warehousing	Public service	Commercial	Settlement	Agriculture	Green Open Space	Open Space	
Agriculture	-	-	-	0.49	96.27	503.01	-	-	599.77
Green Open Space	-	2.93	-	7.32	1.22	-	86.57	-	98.04
Open Space	-	-	-	3.37	37.30	-	-	73.65	114.32
Total Land Area 2016	2.74	5.91	85.12	83.20	1,437.54	503.01	86.57	74.99	2,279.09

According to Table 1, it is stated that the shifts of land use affected by urban activities is majorly happened mainly in open space such as green open space, Open Space and agricultural land that easily converted into built-up areas such as settlement area and commercial area. The biggest conversion of land use was experienced by agricultural land which transformed into settlement areas for 96,27 hectares and commercial areas for 0,49 hectares. The conversion happened also in Open Space which transformed into settlement areas for 37,3 hectares and commercial areas for 3,37 hectares. Moreover, for green open space, the conversion happened into industrial areas for 2,93 hectares, commercial areas for 7,32 hectares and settlement areas for 1,22 hectares. On the top of that, the land conversion was not only happening in non-built-up areas but also for built-up areas such as settlement areas which transformed into commercial areas for around 6,53 hectares and Open Space for 1,34 hectares.

Based on the accumulation of land use changes from 2010-2016, it can be concluded that settlement areas were the most increasing land use which rose 126,93 hectares or around 9,7%, followed by commercial areas which increased 16,5 hectares or 25,2%. Another increasing land use in BWK C during that period was new industrial areas which inclined for 2,93 hectares. On the contrary, some land uses were declining such as agricultural areas which had a big loss for 96,76 hectares or 16,1%, followed by Open Space which dwindled for 38,13 hectares as well as green open space which shrunk 11,47 hectares or 10,8% (See Figure 6).

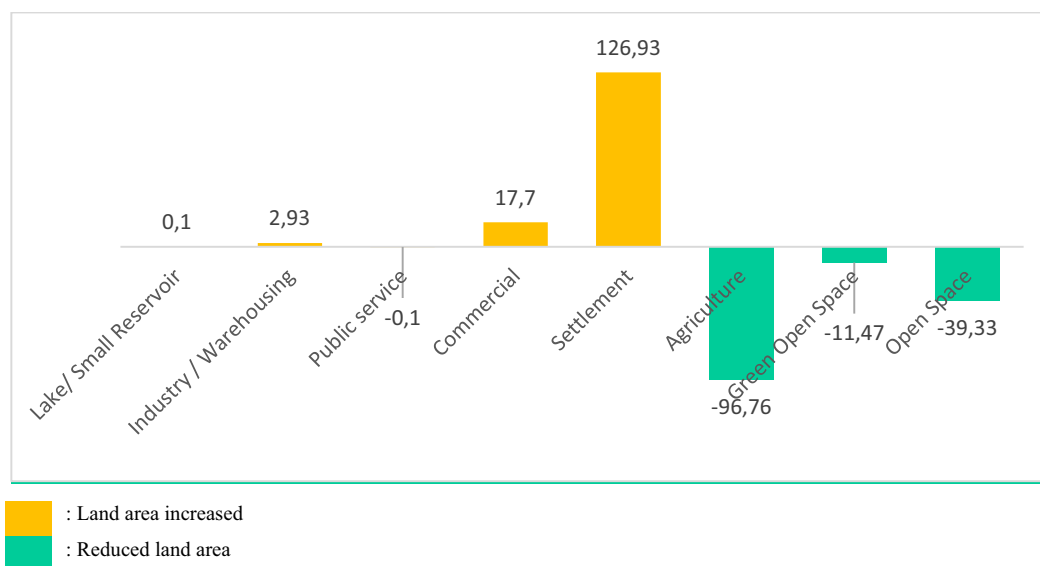


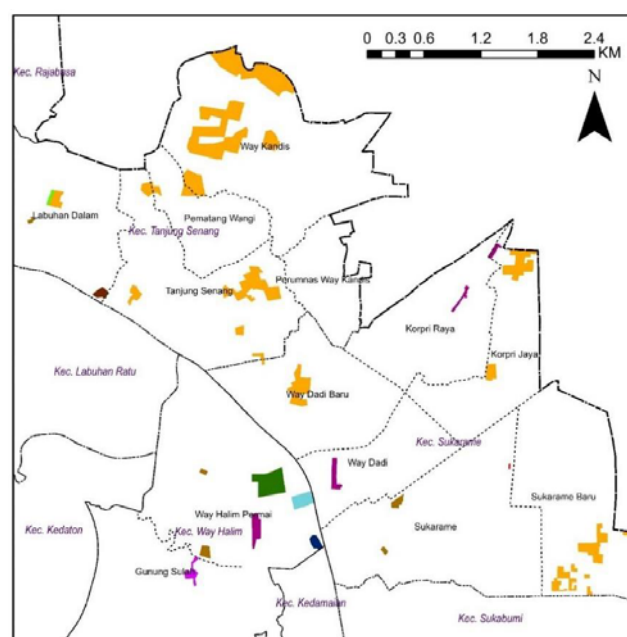
Figure 6. Input-Output Graph Land Use Area (Ha)

Referring to Figure 6 and Figure 7, it can be comprehended that the agricultural land had changed into settlement areas (96,27 Ha) and commercial areas (0,49 Ha). Thus, for Open Space, it was converted majorly into settlement areas (37,3 Ha) and commercial areas (3,37 Ha). In addition, green open space had

changed into settlement areas. Moreover, for the built-up areas, the conversion happened becoming commercial areas (6,53 Ha) and Open Space (1,34 Ha). Generally, the highest increase of land use in BWK C from 2010 to 2016 was for settlement areas followed by commercial areas and industrial areas. On the other hand, the biggest decline of land use in BWK C from 2010 to 2016 was experienced by agricultural areas as it was inevitable consequences of demand due to population growth in BWK C. The conversion of agricultural land into settlement areas is predictable and common symptoms for urbanization specially in a developing peri-urban area. The shifts from agricultural land into settlement areas has been happening in the peripheral area of Bandar Lampung which is adjacent to South Lampung Regency. Unlike the agricultural land changes, emerged in peripheral area, the shifts of settlement area or green space into commercial area led to the city center of Bandar Lampung (See Figure 7).

The city form based on morphological approach or spatial expression of BWK C in the period of 2010 to 2016 had significantly transformed. In 2010, the form of BWK C was not compact and tend to have a split shaped resulted from the distribution pattern of settlement areas. A split shaped is a spatial expression of the city which is not united with the main city, resulting exclaves and usually manifested in the distribution of settlement areas around agricultural land [16]. The settlement area is growing sporadically and connected with unintegrated road networks as its land use pattern. Although some areas of BWK C has been integrated with city center of Bandar Lampung, some peripheral areas near South Lampung regency are growing leaping due to agricultural land distribution. Nevertheless, the development of BWK C is more compact in 2016 as the built-up areas were getting compact and its development was interstitial or heading to inner city. In that sense, the number of built-up areas is increasing, filling the vacant space with the same height of buildings (not-vertically growth).

There are two consequences of city development, namely land intensification towards the urban center and land intensification towards peri-urban areas [5]. Regarding this, the development of BWK C tends to grow towards inner city, indicated by land conversion from non-built up areas into built-up areas such as settlement areas resulting a higher density in BWK C of Bandar Lampung. The spatial expression of BWK C can be categorized as octopus shaped as the transportation networks has been significantly dominant and connected not only one direction but also many directions including to other cities [16]. The availability of open space in BWK C leads to a bigger access and chances for locating any physical development such as the development of settlement areas. However, limited transportation networks in BWK C have resulted a growing development near the prior built-up areas and grew along the road networks. The development of BWK C is more compacted as its built-up areas has increased from 64% in 2010 to 71% in 2016 and the growing development were heading to inner city. The visualization of spatial expression in BWK C can be seen in Figure 8.



Old Land Use (2010)			New Land Use (in 2016)	Area (Ha)
	Public service	→	Lake/ Small Reservoir	0,1
	Settlement	→	Commercial	6,53
	Settlement	→	Open Space	1,34
	Agriculture	→	Commercial	0,49
	Agriculture	→	Settlement	96,27
	Green Open Space	→	Industry / Warehousing	2,93
	Green Open Space	→	Commercial	7,32
	Green Open Space	→	Settlement	1,22
	Open Space	→	Commercial	3,37
	Open Space	→	Settlement	37,3
total area of land use changed				156,87

Figure 7. Identification of the Development of the BWK C Space Structure in Bandar Lampung City with a Morphological Approach

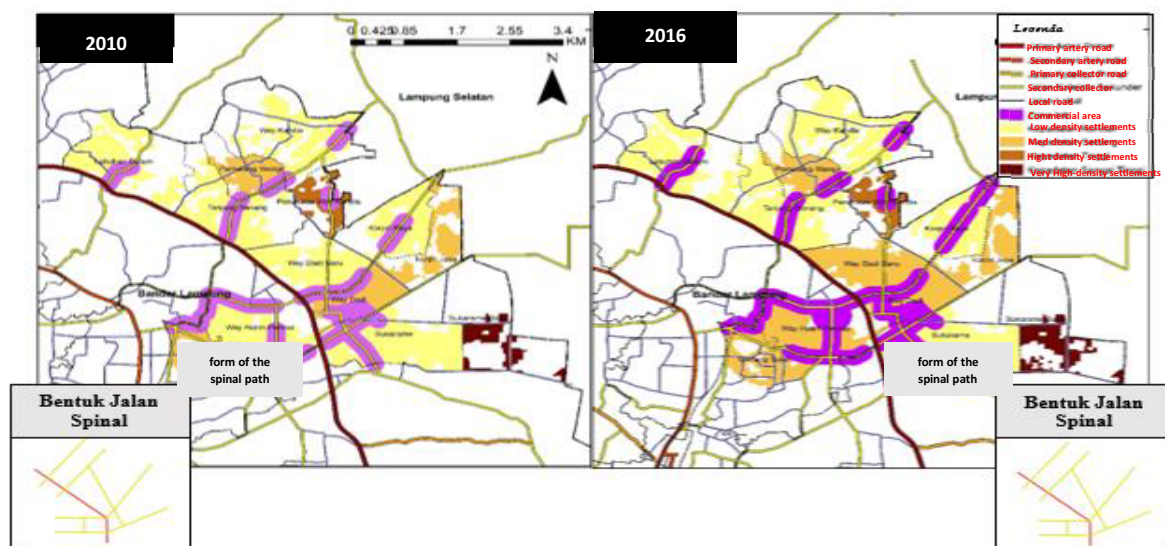


Figure 8. Morphological Expression of BWK C Structure in Bandar Lampung in 2010 and 2016

Table 2. Typology of Morphology of BWK C in 2010 and 2016

Component	2010	2016
Transmission Type	The spreading form cannot be identified because it required land cover data for the period 2004-2010	Based on the 2010-2016 land cover <i>overlay</i> , the built-up land spreaded over the existing road network
Center	Spread out the main road corridor	It appears in the middle of the main center and is scattered by the main road corridors

Component	2010	2016
Settlement Density	High near the Main Street Corridor	High in the Center and Near the Main Street Corridor
Road Network	Spinal	Spinal
Morphology	<i>Ribbon Shaped</i>	<i>Octopus Shaped</i>

Referring to Table 2, it is known that in 2010 BWK C had ribbon shaped and changed eventually in 2016 into octopus shaped due to the increase of built-up areas such as for commercial areas, concentrated in one center and the increase of a higher dense residential areas. Interesting results shown by the concentrated urban activities in Way Halim Permai sub-district as the location of this sub-district is not in a center of BWK C area.

The pattern of commercial area distribution as a center activity in 2010 was going along the corridor of Jalan Sultan Agung, Jalan Ki Maja, Jalan Ryacudu, Jl. Urip Sumoharjo, Jalan Arif Rahman Hakim, Jalan Ratu Dibalau, Jalan R.A. Basyid, and Jalan Endro Suratmin. Meanwhile, in 2016 the commercial area was growing along the corridor of Jalan Ryacudu heading to Institut Teknologi Sumatera and the entrance gate of Trans Sumatera highway which had been built in 2015 and still growing potentially to be a new growth pole of Bandar Lampung. In 2016, the commercial area has been growing along the main corridor of Jalan Sultan Agung, Jalan Urip Sumoharjo, Jalan Ryacudu and Jalan Ratu Dibalau. Those main roads connect all high dense residential areas in sub-districts of Gunung Sulah, Way Halim Permai, Way Dadi and Pematang Wangi.

4. Conclusion

1. During 2010 to 2016, BWK C had experienced a significantly development in the context of social and economic development. The non-physical development of BWK C in Bandar Lampung during 2010 to 2016 could be seen from the growth of population which rose 2,02% annually and around 0,25% higher than national annual rate of population growth. From economic development standpoints, BWK C had been developed as it was shown by the land use for economic purposes such as for commercial areas which increased around 25%.
2. The land use changes from 2010 to 2016 had been dominated by settlement areas which increased around 9,7% and commercial areas which increased 25,2%. On the other hand, the big decline of land use was experienced by agricultural land which decreased 16,1%, followed by the shrinkage of Open Space and green open space which was around 10,8%. The converted agricultural land into settlement areas were happening in peripheral areas of BWK C while in the inner city, the conversion had been dominated by the changes from residential areas into commercial areas as well as along the corridor of main roads in BWK C.
3. The tendency of physical development in BWK C were heading to the city center interstitially as its development were getting compacted. According to morphological indications, BWK C had a ribbon shaped of development in 2010 while in 2016, the shape was changing into octopus shaped as its built-up area development was growing along the main corridors and the spinal road networks.

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