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Mapping Land Use/ Cover Changes and Urbanization at Sub-districts of Muar, Malaysia

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Land use/ cover (LULC) changes in Malaysia are drastic and have caused many environment problems. In Malaysia, LULC mapping often emphasized on municipal level and a few on state and national levels. While, mapping in detail level such as village scale is still in dearth. Hence, this study aims to map the LULC changes in a village scale at urban, suburb and rural areas of Muar. Latest available Geographic Information System (GIS) spatial data year 2010 were obtained from Department of Agriculture Muar. The processing methods mainly involve the operation of GIS and Google Earth. We calculated the percentage of urbanization for every sub-district and selected three plots to compare the LULC changes in year 2010 and 2015, a five years' interval. Results showed that urban area, Bandar Maharani has changed slightly in term of overall LULC. For Sungai Terap, agricultural land has greatly declined because it was converted to barren land and open space for new housing, industrial areas and commodity's plants. For rural area, Ayer Hitam's forest cover has shrunk due to deforestation, and therefore it has led to the increase of barren land. Generally, majority of the agricultural lands are abandoned at urban area. Furthermore, agricultural lands in both suburb and rural areas are in poor condition. In conclusion, mapping LULC in village scale is rather significant even a small change is noticeable which is important to consider, particularly for low carbon and sustainable development.

1. Introduction

As earlier as 1954, Peninsular Malaysia's forest cover was declined from 9.5 million to about 5.9 million hectares in 2008 (JPBD, 2010). In the beginning, forest cover was converted to agricultural land and has significantly contributed to forest fragmentation (Abdullah and Nakagoshi, 2007). Later, agriculture land also threatened by urban sprawl due to the increasing need of new housing area, commercial floor and industrial land (JPBD, 2010). LULC changes have appeared to degrade the condition of environment (Foo and Hashim, 2014). One of it is related to microclimate condition. For example, different type of urban green spaces- lawn, woodland and pave areas will influence air temperature and humidity differently (Chang and Li, 2016). More critically, inappropriate planning that has contributed to calamity such as flood (Tan-Soo et al., 2014) and soil erosion (Foo and Hashim, 2014). As population growth, transformation of LULC to provide more living space is inevitable. But, at the same time, we should also concern not to ruin the environment. Hence, selecting the right place at the right time to suit a right type of development is essential and this can be done through mapping. Mapping LULC has been widely recognised by the scientific community (Prakash and Gupta, 1996) to use it for understanding certain phenomena on the Earth, deriving biophysical information and used in planning and management of natural resources (Lam, 2008). It involves different type of scales for different purposes. In this paper, we defined the scale of LULC according to its administrative boundary. There are others definition of scale for example ecological and institutional scales (Hein et al., 2006). This paper adapted the explanation of scale from Hein et al. (2006) and adjusted to fit the planning system in Malaysia. The scales are categorized as followed: (i) plot (village), (ii) local (municipality), (iii) state (province), and (iv) nation. The range of scale is adapted from Malinga et al. (2014) and adjusted to fit Malaysia context (DoS, 2010) - 2-40 km^2 (plot), 50-700 km^2 (local), 800-125,000 km^2 (state), 130,000-331,000 km^2 (nation). Based on our review, many studies on LULC mapping in Malaysia were focused on municipal level. For example, Baban and Yusoff (2001) mapped LULC on Langkawi Island (390 km^2); Tan et al. (2010) evaluated urban expansion on Penang Island (295 km^2);

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Memarian et al. (2013) investigated LULC impact at the Hulu Langat basin (390.26 km^2) and Leman et al. (2016) evaluated environment sensitivity of Langkawi (478.4 km^2). While, only a few studied on state level (Abdullah and Nakagoshi, 2007) and national level (Miettinen et al., 2016). Meanwhile, research that map LULC changes in village scale, particularly comparison between different gradients are still in dearth. Perhaps, mapping LULC in village scale is unnecessary since mapping in a large scale already provided an overview of the overall planning. But in this paper, we illustrated that mapping LULC in village scale offers better opportunity to reveal those small-sized resources which are often overlooked in local mapping scale. For example, a small green space at local neighbourhood area, open space such as playground, square, street and alley are relatively difficult to illustrate at local scale and far more difficult in state and national scales. This also has been suggested by Miettinen et al. (2016) about the difficulty in classification of LULC, particularly on secondary forest and undeveloped areas. This means mapping in village scale is also rather significant, especially relating to low carbon development since every LULC surface may contribute to carbon emission or carbon storage. Note that this paper only focused on the mapping of LULC and comparison between their changes; questions, issues and how LULC affects the carbon emission and carbon storage are not the main concern of this paper.

2. Study area, material and methods

2.1 Study area

Peninsular Malaysia has many towns and cities that fall under different level of conurbation (JPBD, 2006). This study specifically focused on district growth conurbation due to its richness in natural resources at rural setting (JPBD, 2010). District growth conurbation of Malaysia includes towns in the state of Johor (Muar, Batu Pahat, Kluang) and Pahang (Manjung and Temerloh). In this study, we selected Muar as our study area. Muar is a royal capital, a district of Johor states. Muar is located at 2º3'N 102º34'E coordinate, near the border of Melaka at north, Segamat at east and Batu Pahat at south (MPM, 2013). Muar is also known as a National Furniture Hub that comprises numerous furniture industries (JPBD, 2012). Muar encompasses 12 mukim (sub-districts), namely Bandar Maharani, Parit Bakar, Parit Jawa, Seri Meranti, Sungai Balang, Sungai Terap, Sungai Raya, Jalan Bakri, Ayer Hitam, Jorak, Lenga, and Bukit Kepong (Figure 1B).

Figure 1: A) Map of Peninsular Malaysia. B) 12 sub-districts of Muar. C) LULC data set (2010) of Muar

2.2 Land use and land cover (LULC) data set

The raw spatial data of LULC were obtained from Department of Agriculture Muar (2010) in vector and raster formats. The projected coordinate system is GDM 2000 Johor. The spatial data obtained from the department included both Muar and Ledang districts. Initially, Ledang was considered as part of Muar district. Later, on 9 June 2008, Ledang was declared and upgraded to a district which separated 6 sub-districts including Tangkak, Serom, Kesang, Grisek, Bukit Serampang and Kundang from the border of Muar (LAO, 2016). Therefore, in this paper we only utilized the LULC data of Muar (Figure 1C).

2.3 Urbanization characteristics

According to Gómez-Baggethun and Barton (2013), the definitions of urban area and their boundaries are diverse from every country and subjected to different type of studies such as socio-economic, politic, land use, population, and place (Halfacree, 1993). Generally, urbanization can be determined by several factors such as population density, urbanized land area, and many other social-economic indicators (Su et al., 2012). In this study, we were dealing with mapping of LULC. So, we only measured the physical expansion- built-up areas as the indicator to calculate the percentage of urbanization. In Muar district, LULC is categorized into 11 types: water body, forest, industry, infrastructure and utility, residential area, road, business and service, agriculture,

barren land, open and recreational spaces. To determine the percentage of urbanization, we summed industry, infrastructure and utility, residential area, road and business and service as built-up elements and divided by overall LULC. All the data was keyed in and calculated using Microsoft Excel 2013.

2.4 Data processing and field survey

Three areas were plotted (2.7 km x 1.8 km) based on the percentage of urbanization –high, intermediate and low from urban, suburb and rural areas, respectively. The LULC data set were divided into year 2010 and 2015. For the rural area the latest aerial image acquired was year 2014. Nevertheless, we also performed field survey from September to November 2015 to identify and validate all the LULC data we have had produced based on Google Earth 7.1. The vector data year 2010 (Figure 2A) was updated to year 2015 (Figure 2B) based on aerial image of Google Earth and then clarify onsite. The vector data set year 2010 (Figure 2A) provided by Department of Agriculture Muar (2010) was not really precise and partly inaccurate. Then, we redrew it based on the aerial photo derived from Google Earth. The data processing was separated into several steps as shown in Figure 3. The latest LULC maps after validated on-site were as shown in Figure 4.

Figure 2: A) Raw LULC data set (2010) of Bandar Maharani. B) Updated LULC data set (2015).

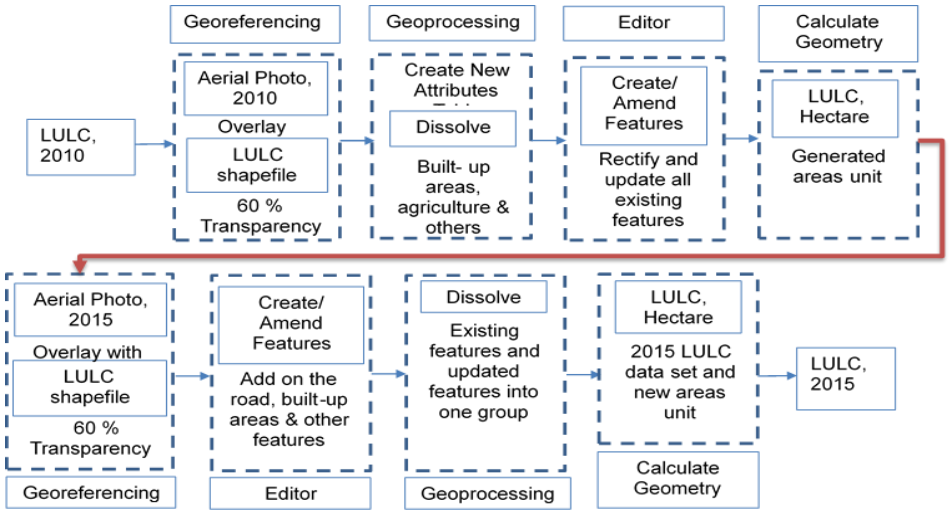

Figure 3: Data reprocessing workflow. Rectify the data set provided by Department of Agriculture and update the data set according to the latest aerial photo derived from Google Earth.

3. Result and discussion

3.1 The overall LULC of Muar and percentages of urbanization

Total land areas of Muar district is 136,870.53 hectares under the boundary of Muar Municipal Council (MPM) administration including the river. In 2010, the highest LULC of Muar was agricultural land (65.02 %) followed by forest cover (26.50 %) and built-up areas (6.92 %). Whereas, others LULC such as water body (1.19 %), open and recreational spaces (0.24 %) and barren land (0.14 %) were low. Muar have 12 sub-districts. Each sub-district has different role to play. Therefore, the LULC for each sub-district also various. For instance, Bandar

Maharani and Jalan Bakri have the highest built-up areas including institutional buildings, residential areas, business enterprises and also infrastructures. While, Parit Jawa, Jorak and Jalan Bakri are mainly focused on industrial development. In term of natural resources, Lenga, Bukit Kepong, Ayer Hitam and Jorak are among the sub-districts that still remains substantial amount of forest covers. The urbanization level of Muar is diverse (Table 1). Bandar Maharani as the urban center has the highest urbanized land areas (39.19 %) and followed by Jalan Bakri (23.83 %). Suburban areas like Parit Bakar (14.23 %), Sungai Terap (13.17 %), Parit Jawa (10.43 %), Seri Meranti (9.12 %), Sungai Balang (8.80 %) and Sungai Raya (8.64 %) are considered moderate urbanized. Rural areas such as Ayer Hitam (6.19 %), Jorak (4.66 %), Bukit Kepong (1.9 7 %) and Lenga (1.61 %) are still not heavily developed.

Table 1: LULC of sub-districts Muar and percentage of urbanization, year 2010.

	BM	PB	PJ	SM	AH	JR	LG	SR	JB	ST	BK
1	141.93	3.08	21.25	16.04	59.01	285.67	432.66	191.84	8.98	190.43	100.49
2	298.03	224.81	83.64	157.32	4483.71	4366.50	15579.47	3.08	-	6.08	9664.40
3	21.92	70.26	182.41	48.69	4.68	121.96	3.18	43.73	123.17	53.55	32.64
4	17.19	2.00	0.18	0.98	0.46	10.96	0.26	0.11	36.35	14.25	2.73
5	137.79	76.25	44.79	42.18	19.74	152.71	34.36	23.12	269.48	7.10	42.56
6	962.32	282.73	217.53	342.96	409.81	309.17	156.51	107.74	424.44	104.73	190.53
7	522.00	148.10	271.00	371.84	289.73	494.95	271.19	153.10	278.05	94.97	232.09
8	113.41	8.89	23.74	8.64	2.33	59.41	4.51	14.28	91.25	9.04	3.26
9	2,029.83	3,312.52	6,249.39	7,952.01	6,460.87	18,873.92	12,655.35	3,397.28	3,794.95	1,637.81	15,349.54
10	120.40	-	-	2.23	-	-	-	14.19	37.04	13.22	0.98
11	164.00	4.32	0.51	-	20.59	8.29	8.94	13.06	67.00	23.15	14.38
T	1,774.63	588.23	739.65	815.29	726.75	1149.16	470.01	342.08	1,222.74	283.64	503.81
U	39.19 %	14.23 %	10.43 %	9.12 %	6.19 %	4.66 %	1.61 %	8.64 %	23.83 %	13.17%	1.97 %

Acronyms: BM- Bandar Maharani, PB- Parit Bakar, PJ- Parit Jawa, SM- Seri Meranti, SG- Sungai Barang, AH- Ayer Hitam, JR- Jorak, LG- Lenga, SR- Sungai Raya, JB- Jalan Bakri, ST- Sungai Terap & BK- Bukit Kepong.
1- Water body, 2- Forest, 3. Industry, 4- Infrastructure and utility, 5. Institutional area, 6- Residential Area, 7- Road, 8- Business and services, 9- Agriculture, 10- Barren land, 11- Open and recreational space, T- Total built-up areas, U- Percentages of urbanization. All areas unit in Hectares (ha)

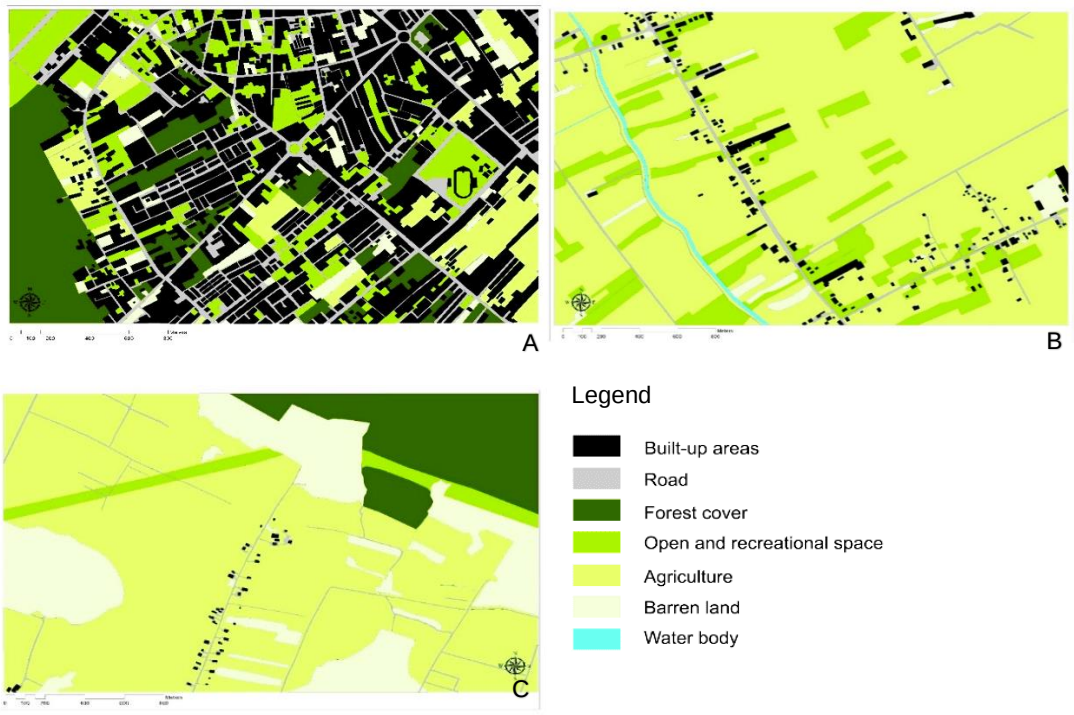

Figure 4: LULC maps of Bandar Maharani (A); Sungai Terap (B); Kg. Pt. Haji Zain, Ayer Hitam, yr 2015 (C).

3.2 LULC change in the year 2010 to 2015

From what we have had mapped, Bandar Maharani as the urban center did not change much in term of overall LULC (Figure 5). Generally, built-up areas, roads, agricultural lands, and open and recreational spaces have increased slightly. Whereas, barren lands and forest covers have decreased. The reasons of the increasing of built-up areas were due to the increasing needs of new residential areas and business and services opportunity as stated in the local planning plan (JPBD, 2012). Most of the new built- up areas were constructed at the existing abandoned agricultural lands and barren lands while some at forested areas.

LULC of Sungai Terap mainly focuses on agricultural development. The agriculture includes oil palm plantation, rubber estate, durian estate and orchards with mixed cultivation of fruit trees. Sungai Terap has changed drastically in term of agriculture (Figure 5). Some of the existing agricultural land were replaced with newly growth commodity's plants - oil palm. While, some of the agricultural lands were transformed to barren lands and open space for new housing and industry development. For Ayer Hitam, agriculture is among the highest LULC, quite similar to suburb area. The only difference is rural area also covers with substantial amount of forest covers (15.93 %) during 2010. The forest covers at Ayer Hitam is listed under environment sensitive areas due to its richness of flora and fauna. Somehow, a portion of the forest covers near the east side (Figure 4C) were deforested due to unknown reason. Most likely, it will be replaced with other commodity's plants that generate more profit to the stakeholder.

This potentially will contribute to the diminishing of goods and services that forest ecosystem provided such as carbon sequestration, air purification, clean water, timber and medical resources (TEEB, 2011). And it may subsequently lead to soil erosion due to deforestation (Foo and Hashim, 2014). Besides, there is also quite extensive of barren land at Ayer Hitam which is not functional because the land remains unproductive and not capable to produce any goods. From the field survey, we noticed that most of the agricultural lands are deserted at urban area, only few orchards fruit plantation are still in good condition. While, agricultural lands in both suburb and rural areas generally are in poor state; some of them overgrowth with bushes and cogon grass while others seem not being properly managed and maintained. This happened due to there is no enough youngster to continue their family businesses and they are more prefer to migrate out to urban city (JPBD, 2010).

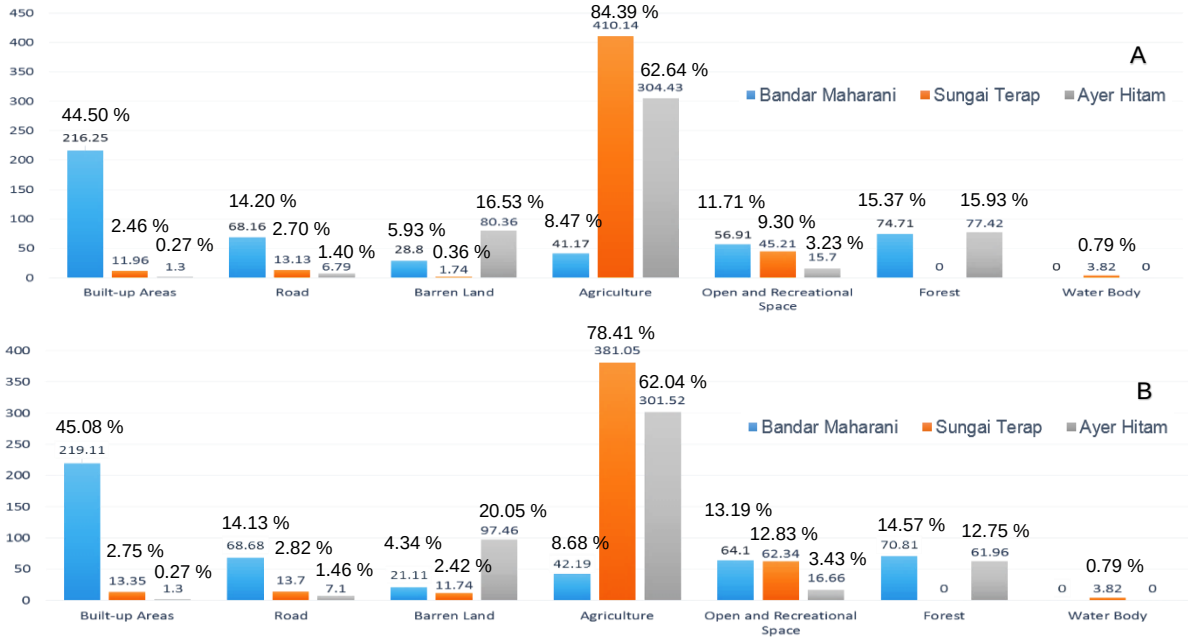

Figure 5: LULC of urban, suburb and rural areas, year 2010 (A); year 2015 (B). All units in hectares.

4. Conclusion

Muar district still has many forest cover, despite many have been converted to agriculture and built –up areas during early 1950s. And to-date, one of the problems is, most of the agriculture are in not-so-good condition. In addition, forest covers are also declining slowly. One of the major concern is, these resources are not being properly recorded, mapped and updated, regularly. Second, there is a lack of evaluation on natural resources. For example, how LULC influences carbon storage and emission. Another issue is lack of awareness among the public and stakeholders about the benefits that they can obtain from natural resources besides the economic value. In this paper, we emphasize that the mapping of LULC in village scale based on field survey data and

satellite image is indeed important. First, it allows us to scrutinize those small-sized resources, such as small patches of green and open spaces which may benefit the local residents for recreational activities. Furthermore, we can identify and record the detail condition of the plants, for example trees size and leafs density. With such detail, the LULC data sets can be further developed and analysed to suit other research fields. For example, it can be used to calculate how much carbon can be stored in a green space, and how much carbon is emitted from built-up areas. Essentially, this may spark some ideas for planners and designers to come out a real sustainable solution and low carbon development.

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