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Urban Expansion Analysis using Semi- Supervised Image classification (SSIC) of Landsat-5 image: a case study in Kuantan, Malaysia

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Abstract:

This study aimed to evaluate and investigate the dynamics of urban growth in the city of Kuantan, using Semi- supervised classification of Landsat-5 time series. The methodology is purposed for SSIC by incorporating high resolution of Google Earth images which is available in different date and times for many places. The Land-5 (TM) Images of 1993, 1999 and 2010 were employed for calibration and correction for atmospheric noise to ensure accuracy of LULC analysis. The images were then categorized into distinguished feature classes for locating training samples areas for SSIC classification. The overall accuracy of each classification were estimated to be 82% in 1993, 1999 and 80% in the year 2010, which reveal SSIC provide a good level of agreement with the kappa coefficient values ranged from 0.789 to 0.761. However, obtained result also revealed the notable increased urban pattern in the study area. The growth trend over the last decades has produced over all 15.52 % north-easterly during the 17 years. The proposed method of assessing Urban Expansion (UE) in Kuantan based on semi- supervised method were validate with freely online source i-e Google Earth. The acquired results show the virtuous accuracy level. The study found, SSIC approach as the reliable, cost effective and time saving techniques. It also enhances the online sources as an alternative for verification of images classification when there is the lack of financial assistance to arrange field survey or and sparse availability of referenced maps.

Keywords: Kuantan, LULC, Landsat-5, Urban Expansion

1. Introduction

The Information of Land use/Land cover (LULC) modification is an important component for the sustainable environmental planning and management. It is required to monitor the changes of LULC under the diverse demographic conditions. Since last decades, it has been reported the urbanisation is the major cause of brought changes in LULC states(Weng 2001). Recently, assessment of LULC has become an essential factor of environmental process and climate changes(Aguilar, Ward et al. 2003). The term urbanization refers to the conversion of land use part into built-up land or urban land (Weber 2003).The assessment of urban expansion through field survey and mapping approach is some times and cost effective, especially in emerging states. Therefore, there have a growing interest of using remote sensing (RS) and geographical information system (GIS) techniques to detect and monitor the urban trend(Epsteln, Payne et al. 2002).The integrated approach of RS and GIS considering influentially effective approach to appraise the trend of urban expansion (Harris and Ventura 1995, Yeh and Li 1997).Kuantan the city of East Coast part peninsular Malaysia, has been going to experience changes in LULC. In the result of majority of population started migrating from rural to urban areas for economic and social cause. This paper objects to use landsat-5 time series data in order to quantify the dynamic

changes in LULC in the process on urban expansion over the past 17 years. Such substances are required to support an effort for sustainable Land use planning.

2. Description of Study Area

The area of research, Kuantan Malaysia's third largest state and capital of Pahang, is located within the coordinates 3.81° N, 103.33° E. Kuantan is considered the social, economic and commercial hub for the East Coast of Peninsular Malaysia due to its considered locality. Geographically Kuantan cover the area approximately, 2,960 km^2 with elevation 21.95 m from sea level. It considers one of the largest cities in east coast part of Malaysia with projected population of 700,000. In present state, Kuantan is undergoing to rapid development with growing modernism with in the city.

Figure 1 : layout of the study area

3. Data and Methods

3.1. Satellite Images

The source data Landsat-5 TM sensor consist seven spectral bands including one thermal (60 m) and six (30 m) reflective with different range of wave length detail shows in table (1).The images of April 4th 1993, March 8th 1999 and February 7th 2010 were acquired from USGS for performing land use classification. The collected images contained clouds cover 15% (April '93), 5% (March'99) and 12% (Feb '2010) with covering the path 126 and row 57. To minimize the effects of atmospheric noise, the radiometric calibration has done before classification.

Bands	Colour Depiction	Resolution	Wavelength (μm)
1	Blue	30m	0.45-0.52
2	Green	30m	0.53-0.61
3	Red	30m	0.63-0.69
4	Near Infrared	30m	0.78-0.90
5	Short-wave Infrared	30m	1.55-1.75
6	Thermal Infrared	60m	10.4-12.5
7	Short-wave Infrared	30m	2.09-2.35

Table 1: Information about Landsat 5 sensors

3.2. Land-use Land-cover Changes

The approach of semi-supervised classification assisted to investigate the changes in LULC in Kuantan using well accepted method of maximum likelihood classification (MLC). MLC criteria based on theory, explained by to (Jia, Liang et al. 2014) that the vector feature of classes could be used to compute the likelihood of unknown pixel in each class. Therefore, the maximum probability of pixels considered to belong to the assigned corresponding feature class. LULC classes were categorized into water body, built-up land, agricultural land, forest and bare soil. The sample training areas were created based on visual interpretation on image to recognize the land use feature classes. Spectral analogous sub-areas were then demarcated with specified class name using training signature. The classification accuracy of each images were carried out by employing the fundamental of error metrics and Kappa coefficient statistic (Kc). In this study, random points were generated, from the referenced online available data source i-e Google Earth. The Google Earth offers high resolution satellite imageries in different date and times for the most of places. The error matrix described the level of accuracy between the referenced points and classified values of the same image(Foody 2009).The detailed statistical analysis of SSIC classifications using Kappa cofficient (k_c) and the overall accuracy for the KRB LULC change detection were determined by given Eq.1 and 2.

$$\text{Overall Accuracy} = \frac{Sum\ of\ true\ random\ points}{Cumulative\ sum\ of\ all\ random\ points} \quad (1)$$

$$k_c = \frac{Observed - Expected}{1 - Expected} \quad (2)$$

4. Results and Discussion

4.1. Urban Expansion Analysis

The overall accuracy of the all classified images were assesst using error metric. The overall accuracy of each classification were estimated to be 82% in 1993, 1999 and 80% in the year 2010, which reveal SSIC provide a good level of agreement with the kappa coefficient values ranged from 0.789 to 0.761(see table 2). However, obtained result also discovered the notable increased urban pattern in the study area. UE was considering by counting the cumulative sum of pixels covered built up land in

all three images. The growth trend over the last decades has produced over all 15.52% north-easterly during the 17 years. Figure 2. Shows the map of urban extent which was created by overlapping the built-up areas extracted from classified images. The classification results in figure 3. Indicate the significant increase in urban spatial extent from 26.43 km^2 to 129.27 km^2 in 1993 to 2010.The reason for UE in Kuantan is due to rapid increase in population growth. According to National Physical Plan (NPP) by the department of town and country planning of Peninsular Malaysia(see http://www.kicc.jp/), Kuantan served as the main contributor of commercial and industrial field s in the eastern part of peninsular Malaysia and has major influenced of rapid population growth. In addition, it has also sated by (Mohd Fadzil bin Mohd Khi, 2005) the ratio of population growth in Kuantan from 1991 to 2010 was 3.81% from 255,974 people to 503,450 people. Therefore, the development of Kuantan is continuous to grow with. Since the People started to more civilized and migrating from rural to urban areas. However, the increased trend of urbanization brings modification in LULC resulting the land surface degradation and removal of soil as well which ultimately fluctuate the rainfall runoff relationship and flood occurrences(Konrad 2003). In addition, the main objective during the development of urban areas is to make the sustainable management plan in order to enhance the quality of life and to protect natural resources from damage. Hence, the continuous monitoring and assessment of LULC situation will help the land planning authorities to accelerate the improved management to protect the environment.

Landsat 5	Overall accuracy (%)	Kappa coefficient (kc)
April 1993	82	0.789
March 1999	82	0.789
February 2010	80	0.761

Table 2: Accuracy Assessment of LULC (1993 to 2010)

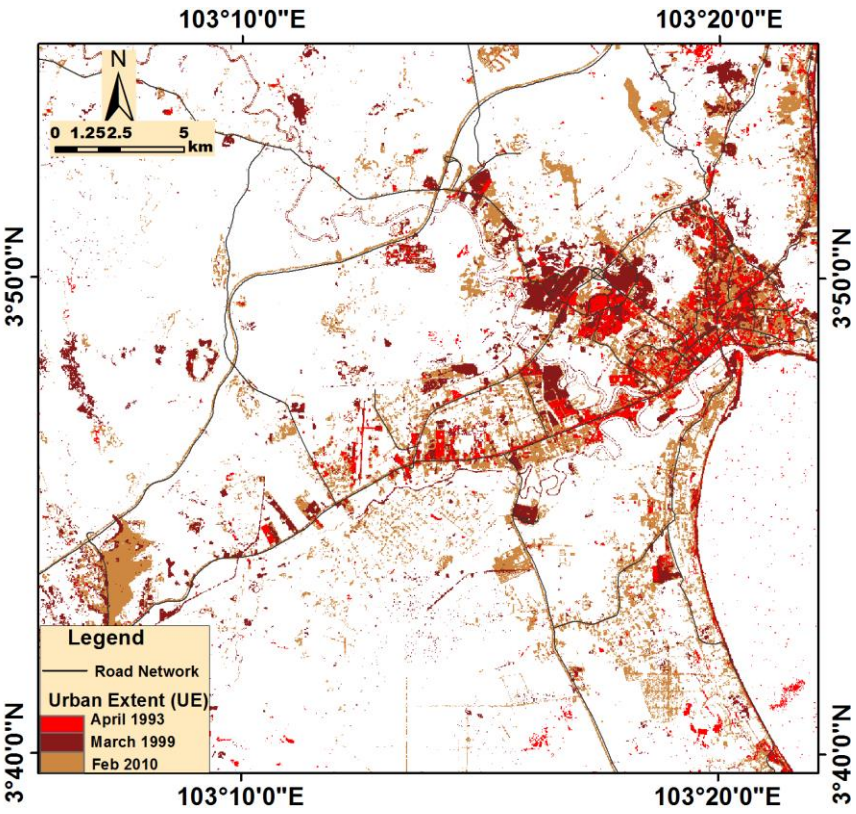

Fig. 2: Urban Extent (UE) Map from 1993 to 2010

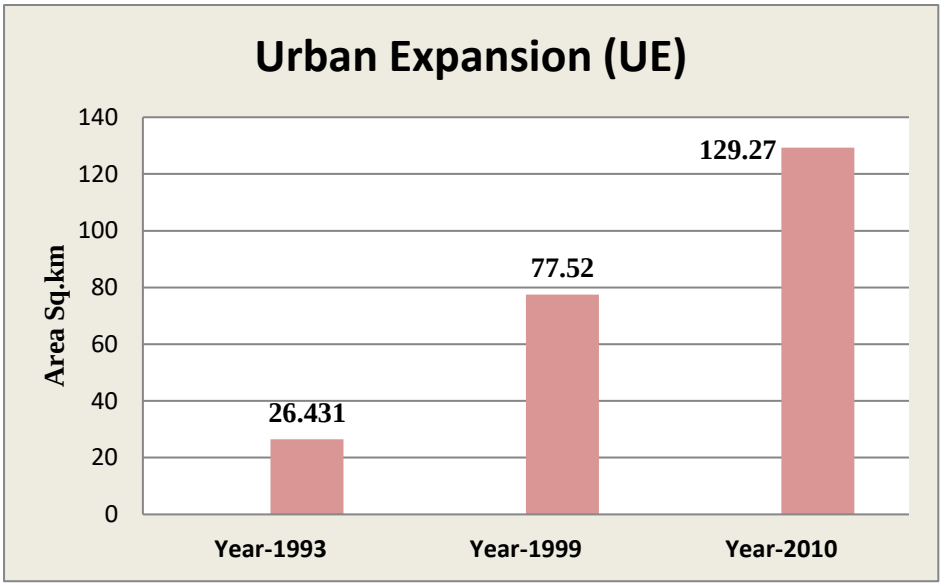

Fig. 3: Urban Extent (UE) Map from 1993 to 2010

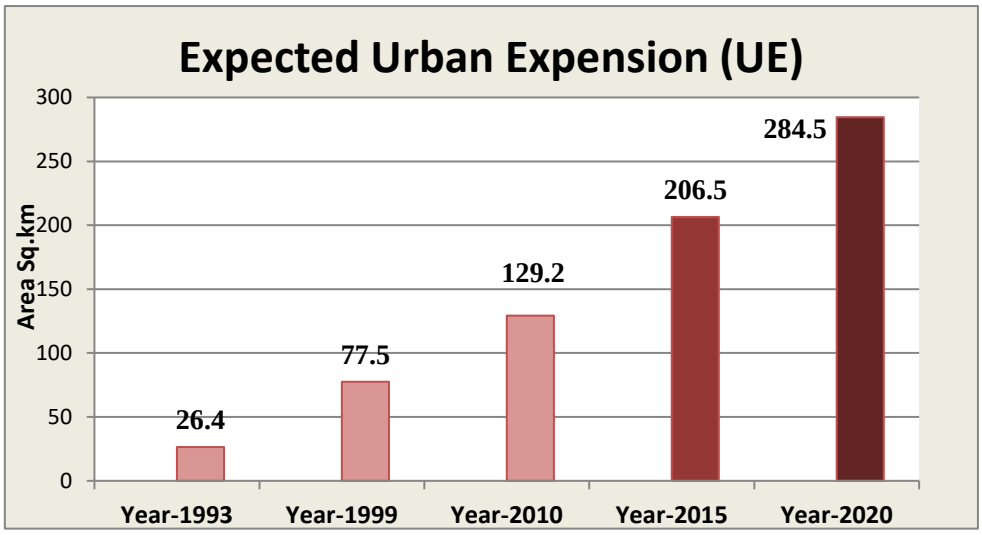

Fig. 4: Expected Urban Extent (UE) Map from 1993 to 2020

5. Conclusion

According to the result from this study, rapid growth of urbanization is observed during 1993 to 1999 with 33% (1.96% per year) increasing build-up areas. Increasing in urbanisation has been continued from 1999 to 2010 but with lower rate of 0.7% per year. It was about 6.1 % increase in 11 years period. The economical crises faced in Malaysia during the period could be on of the lower rate of urban increase. However, in average the total of urban expansion since 1993 to 2010 (17 years) is estimated approx. 15.52% which can be calculate the future expansion of build-up lands in Kuantan. Considering 15.52% growth rate for urbanization in the study area lead to predict future expansion of urban areas which are 206.5 km2 and 284.5 km2 shown in Figure 4 for the years 2015 and 2020 respectively. According to this study, it can be expected is This study shows that the information acquired from

LULC classification can be more helpful for policy maker in order to make protective and sustainable land planning. In the study, the approach of semi-supervised classification has used which shows the reliable accuracy assessment. The classification used the online source Google-earth as the referenced map to rectify the level of classification accuracy. The advantage of using Google-earth for assessment is to provide quick way of monitoring land surface with the saving or time and cost. Especially, it is beneficial for remote areas where it is difficult to arrange the field survey because of cost and transport constraints and also there is scarce availably of topographic maps of the area.

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