

# Impact assessment of rapid development on land use changes in coastal areas; case of Kuala Langat district, Malaysia

Sharareh Pourebrahim · Mehrdad Hadipour · Mazlin Bin Mokhtar

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**Abstract** The first large urban conurbation in Malaysia stretching from the central mountain spine to the west coast has expanded all rounds to emerge as a potential mega-urban region. It covers the area from the Bernam River basin in south Perak to the Linggi River basin in Negri Sembilan. The analysis of the land use change patterns and the prediction of future changes can highlight the problems of continuing current pattern of growth. Kuala Langat as the case study is located in the strategic area, because this area is identified as a Klang Valley II. The district has been experiencing rapid development, influence by some fast growing new centers like Kuala Lumpur International Airport, Klang Valley, Cyberjaya, Putrajaya and Kuala Lumpur mega-urban region. These have caused degradations of the natural habitats located in this area such as forests, peat swamp, mangroves and wetlands and land use changes from forest and agriculture to development areas. Also some sensitive area such as reclaimed lands, geo-disaster area, flash flood prone areas, dumping grounds and high erosion area need urgent sustainable plan for future development. Also, coastal lands are being developed very fast through establishments of residential, industrial and commercial centers. The analysis of land use changes have led to a better understanding in exploring suitable growth pattern for future development. The land use map obtained from Department of Agriculture for the year 1974 and 1981 and data of Landsat TM for the years of 1988, 1991, 1996 and 2010 obtained from the Malaysian Center for Remote Sensing were analyzed using GIS. From the investigation of

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S. Pourebrahim

Department of Environmental Science, Faculty of Natural Resources, University of Tehran,  
3158777878 Tehran, Islamic Republic of Iran  
e-mail: sh\_pourebrahim@ut.ac.ir

M. Hadipour (✉)

Department of Environment, Faculty of Agriculture and Natural Resources, Arak University,  
PO Box: 4314, Arak, Islamic Republic of Iran  
e-mail: mhadipour50@yahoo.com

M. B. Mokhtar

Institute for Environment and Development (LESTARI), National University Malaysia (UKM),  
43600 Bangi, Selangor, Malaysia

land use changes detection over 35 years, the current unsustainable pattern of growth was highlighted. This emphasizes the urgent need for a sustainable development plan.

**Keywords** Coastal land use planning · Change detection analysis · Remote sensing · GIS

## 1 Introduction

Coastal areas, because of the services they provide, are important regions for human activities (Douven et al. 2003). Malaysia has about 48,000 km of coastline and about 70 % of the Malaysian population live in the coastal zone. Therefore, the coastal zone has become the center of urban and rural economic activities (EPU and DANCED 1999). Kuala Lumpur mega-urban region bounding an area of about 200 km, north–south and about 50 km east–west. This area from the mountain spine to the Straits of Melaka with an estimated population around 7 million people in 2013 and expected to be increased about 10 million by the year 2020 have some critical impacts in coastal areas. Figure 1 shows the Kuala Lumpur mega-urban region.

Kuala Lumpur maintains its position as the national growth center commanding the dominant Klang valley conurbation. More development drivers entered the conurbation beyond the 1980s that bolstered spatial expansion of urban areas from the existing centers to the north and south following more people coming to make their homes in the area (Hadi et al. 2010).

Based on UN-Habitat report (2005), it is expected that, by 2020, two-thirds of the entire Association of East Asian States (ASEAN) urban population will live in only five mega-urban regions (MURs) and the Kuala Lumpur–Klang MUR is one of. East Asian MURs are introducing urban issues on geographic scales never before experienced. This is probably associated with the rapid industrialization that has occurred during the last few decades. In this case, coastal areas as the most important regions for human activities due to the services they provide will be under pressure from a range of activities whose natural performances have been threatened by short-sighted planning policies. (Pourebrahim et al. 2010, 2011).

With rapid population growth and economic activities, town planning in those days were arbitrary with rather unhealthy with unsanitary conditions (Mokhtar and Ghani Aziz 2003). So, there was a need to design integrated approaches for sustainable coastal land use development, applying techniques such as Remote Sensing and GIS, to make the best decision (Brody et al. 2004). The objectives of this study are to explore the land use changes that have taken place in the last over 35 years to show the rapid impacts of urbanization with respect to continued growth and to examine the capabilities of integrating remote sensing and GIS in studying the spatial coastal land use changes. The research was focused not only on the land use changes during the different historical period but also on determination and overview of related driving forces. The study of driving forces is problem oriented and in practice not restricted to a specific method or framework (Bürgi et al. 2004).

In this research, because the planning process in Malaysia is implemented by mukims (sub-districts), the study area boundary is therefore based on mukims. Land use change patterns over 35 years are considered and some impacts of development assumed by continued pattern from the past have been shown.

# Kuala Lumpur: Extended Mega Urban Region (KL - EMUR)

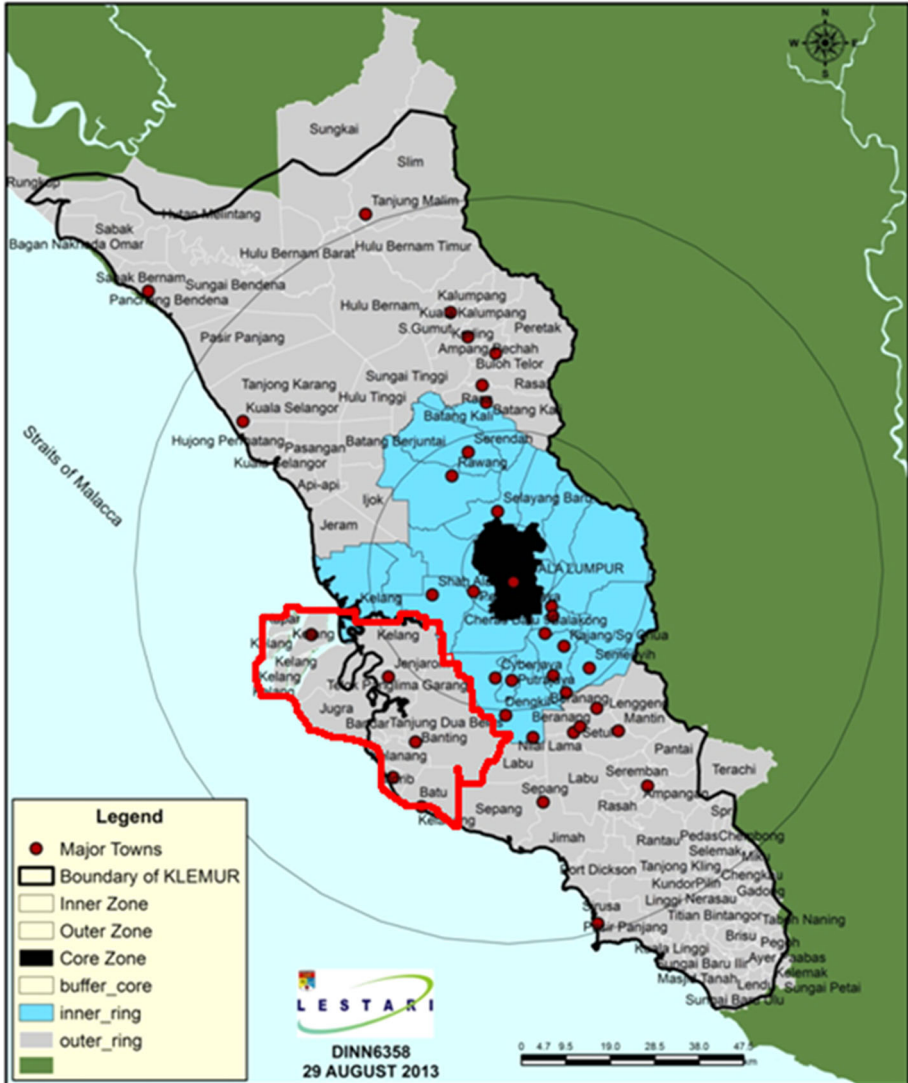


Fig. 1 Kuala Lumpur mega-urban region

## 2 Study area

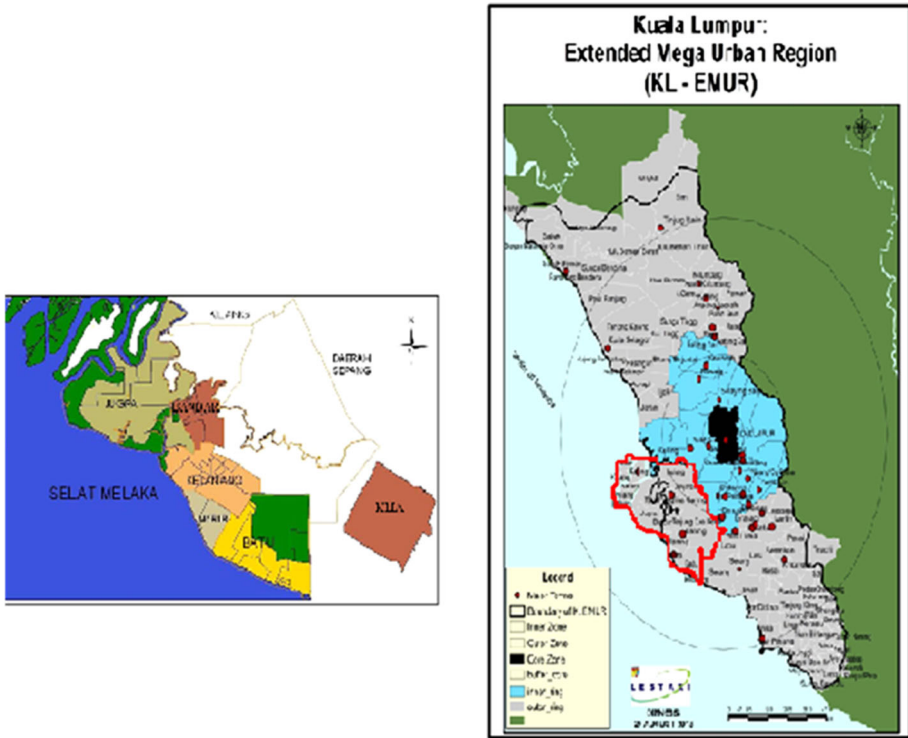
The study area selected is the Kuala Langkat district. It is located in Selangor, Peninsular Malaysia. The Strait of Melaka is on the west of this district, making the latter a coastal district (Fig. 2). This study area was chosen because the district is under rapid

development. However, it needs urgent sustainable plan for future development. It is very close to Kuala Lumpur mega-urban region, near some fast growing new centers such as the Kuala Lumpur International Airport (KLIA). It was a part of one of the six National Integrated Coastal Zone Management Demonstration Projects in East Asia. The study area is almost entirely flat with the exception of Jugra Hill (232 m). Population density is relatively low and urban centers are widely scattered. Agricultural plantations occupy most of the intervening space. Two large patches of peat swamp forests existed inland while the coastline is intermittently vegetated by mangrove swamp and strand forests.

### 3 Methodology

Two sets of data were used to investigate land use changes. Firstly, the land use maps (paper maps) obtained from Department of Agriculture of Malaysia (Scale 1:25,000) for the year 1974 and 1981 were used to show the different land use categories. The paper maps were firstly scanned and digitized using Arc Info NT version 8.0.1 and Arc GIS 9.2. The resulting digital images were then co-registered using a nearest-neighbor re-sampling algorithm to the 1991 geo-referenced TM images (for which the geographical coordinates were extracted from topographical maps obtained from Department of Survey and Mapping with Scale 1:50,000) using as ground control points land features. Some unchanging sites and landmarks such as rivers and road intersections were used for this part. Then, all the features and boundaries of the different land cover units were digitized. Also using designed model filter on 1991 map, the noise produced by the discrepancy between the more detailed outline of TM maps and the hand-drawn outlines of the paper maps units were minimized. It helps to produce outlines that better resembled those of digitized paper maps.

Secondly, data from Landsat TM with 30\*30 meter resolution for the years 1988, 1991, 1996 and 2010 were obtained from the Malaysian Center for Remote Sensing and were analyzed. These were used to find land use changes using ERDAS 8.3 software. Landsat Thematic Mapper for the years 1988, 1991, 1996, and 2010, were then used to prepare a digital base map of the Kuala Langat district. Satellite data were geo-coded and projected to a RSO grid using Kertau 1984 datum. The image was initially classified using unsupervised classification. It is used as a guide in selecting sites for the supervised classification process. Eight initial land cover categories were identified using the maximum likelihood method followed by a post-classification process. Topographical maps were used for geometric correction of the satellite images and land use maps and field observation were used for accuracy assessment and with help of GPS these data were localized. They were used as preliminary abstractions of land use information were found to be useful in image interpretation. Recent land cover and land use maps as well as ground information were also employed for the purpose of supervised classification and classification accuracy assessment. Maximum likelihood supervised classifications were performed in ERDAS IMAGINE 9.3 on the 1992 and 2007 Landsat images. For each class, ground-truth polygons were digitized based on visual analysis of locations on Google Maps and the image itself. Each polygon contained at least 50 pixels (Jensen 2005). To improve classification, training polygons with confusing spectral signatures were discarded and new ones created based on a visual analysis of the locations in Google Maps and on the image itself, and these were added to the existing samples and the maximum likelihood algorithm was run again. Pixels throughout the classified image were visually compared with the raw image and Google Maps to determine classification accuracy. This process was repeated until the



**Fig. 2** Location of study area very close to Kuala Lumpur mega-urban region

observable errors in the classification were negligible. For the 2010 image, 259 points were selected randomly on the map that each class had at least 50 points and checked for accuracy using fieldwork ground-truth data. These points were checked against the reference data. The results of accuracy assessment showing both the confusion matrix and the kappa statistics has been presented in Table 1. All data were integrated in GIS and change detection analyses have been carried out using algorithms developed in GIS environment.

The reason of choosing different years in different decades was to investigate growth patterns related to policies and plans. The first available maps for analysis of land use changes were for the years 1974 and 1981. These maps were chosen for analysis, because they fell within the decades of the 1970s and 1980s. It was during these periods that a new economic policy was implemented. In the National Malaysian Plan, the government focused on urbanization of rural areas and moving to industrialization. The Third Malaysia Plan (1976–1980) started with urbanization. Data from the 1990s were important, because there were strong growth of construction industries and socioeconomic forces attributed to urbanization. The 2010 land use map was used to show the changes in land uses after some critical projects such as KLIA, KL-EMUR and new urbanization such as Cyberjaya and Putrajaya. The classification of the land uses and land covers have included agricultural, forests, bare lands, water bodies and developed area. Types of forest included are as follows: mangrove forest, peat swamp forest, dipterocarp forest and lowland forest. The analysis of land uses in each map for the different years was done using Excel software.

The behavioral patterns of individual land uses were presented and the growth patterns could be represented by formula or shapes.

#### 4 Results

Based on descriptions in methodology, the results of accuracy assessment are shown in Table 1.

The overall accuracy for the 2010 classified map based on the supervised classification was 93.05 which are considered good, and it is above the limit set by USGS guideline (85 %). Because the overall accuracy assessment tends to overestimate the actual performance, a more useful representation of performance is the kappa coefficient (Cohen 1960). The kappa coefficient for the supervised 2010 image was 0.91 which means that 91 % of the classification is better than a random classification. This is considered good because a kappa value above 80 % is considered to have a strong agreement. The results of land use changes in Kuala Langat district over 35 years are presented in Table 2. They have led to a better understanding of rapid growth after urbanization and some critical changes on environment.

The Table 2 showed that agriculture is the major land use activity in the study area. In 1974, 51.85 % of total area was used for agriculture area followed by forest (41.71 %). The developed areas in 1974 were estimated as 0.58 % and at that time, this was relatively insignificant, attributed to low population density and government emphasis on agricultural activities. Data in 1981 showed similar patterns as that of 1974, but the forest land cover had decreased significantly to 31.37 %, agricultural activities increased to 62.02 % and developed areas increased slightly to 0.81 % in 1981. The year 1988 showed a huge change in term of forested area especially the peat swamp and mangrove forests. Forested area decreased to 20.94 % within 7 years from 1981. Major changes were found in areas of peat swamp (9.50 %) followed by mangrove which lost 11.15 % of its total area. Developed areas had increased to 1.66 % and agricultural activities increased as well to 71.02 %. Within 7 years since 1981, forest areas had been converted to facilitate agriculture. In 1991, there were minor changes in land uses, whereby the agriculture average had increased to 73.4 %. Agricultural activities still dominated, followed by forests, the later

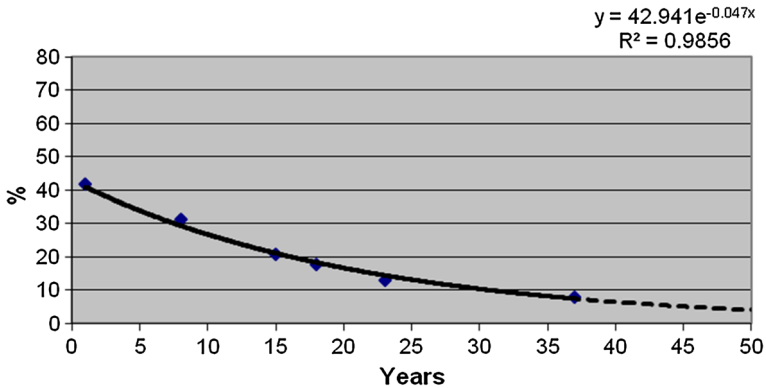
**Table 1** Results of accuracy assessment of 2010 land use map produced from Landsat TM data, showing the confusion matrix and the kappa statistics

Classified data	Reference data						Row total	User's accuracy (%)
	Forest	Agriculture	Bare lands	Developed area	Water bodies			
Forest	48	2	5	1	0	56	85.71	
Agriculture	3	54	0	6	0	63	85.71	
Bare lands	0	0	45	1	0	46	97.83	
Developed area	0	0	0	44	0	44	100.00	
Water bodies	0	0	0	0	50	50	100	
Column total	51	56	50	52	50	259		
Producer's accuracy (%)	94.12	96.43	90.00	84.62	100.00	Total accuracy	93.05	

$$\text{Kappa} = 0.930 - 0.201/1 - 0.201 = 0.912$$

**Table 2** Land use changes analysis in Kuala Langat over 35 years (1974–2010)

GRIDCODE	1974 (ha)	%	1981 (ha)	%	1988 (ha)	%	1991 (ha)	%	1996 (ha)	%	2010 (ha)	%
Forest	1,691.07	41.71	1,271.55	31.37	849.02	20.94	716.05	17.66	523.14	12.90	327.36	8.08
Agriculture	2,102.17	51.85	2,514.20	62.02	2,879.19	71.02	2,975.62	73.40	3,157.92	77.90	3,117.99	76.89
Bare lands	103.87	2.56	103.38	2.55	127.76	3.15	132.90	3.28	137.52	3.39	79.34	1.69
Developed area	23.55	0.58	32.70	0.81	67.40	1.66	97.90	2.41	105.57	2.60	407.10	10.04
Water bodies	133.34	3.29	132.03	3.26	130.62	3.22	131.53	3.24	129.85	3.20	123.09	3.04
Total area	4,054.00	100	4,054.00	100	4,054.00	100	4,054.00	100	4,054.00	100	4,054.00	100



**Fig. 3** Forest change pattern in Kuala Langat district

showing a decrease of about 17.66 %. Forested areas were converted mostly to agricultural and developed areas, because of economic and social development emphasized under the New Economic Policy (1971–1990). The decrease of agricultural area, forestry and increasing developed area in 2010 is testimony to a focus from agriculture and forestry to urbanization and industrialization, due to the influence of commodity price exchanges during the periods of decline. The results of land use change for the year 2010 showed that some serious environmental issues will surface, if the development of the land use pattern continues at the present growth rate. Also, because of some huge projects, these changes should be faster. In this study, with the current pattern, the change of land use was predicted for 2025. Figure 3 shows forest change pattern. The pattern of forest changes showed that if the current unsustainable development continues, the forest area would have reduced to 3.73 % in 2025.

Forest land use encountered rapid changes in three decades. The results of forest change analysis are shown in Table 3. In 1974, the forest occupied 41.71 % of total land area, while in 1981, 1988 and 1991 this land use had decreased, respectively, to 31.37, 20.94 and 17.66 %. In 1996 and 2010, the forested areas continued to decline to 12.90 and 8.08 %, respectively. The pattern of forest changes showed that if the current unsustainable development continues, the forest area would have reduced to 3.73 % in 2025. It is observed that the reduction of mangrove forest and peat swamp had happened rapidly (Table 2). As the results shows, the rate of changes during 1996–2010 is very fast.

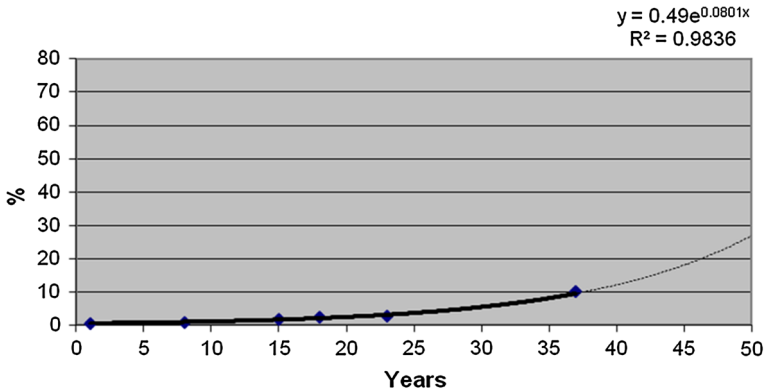
In 1974, mangrove forest covered 21.06 % of study area. It had decreased to 15.46 % in 1981, 11.15 % in 1988, 9.06 % in 1991, 5.87 % in 1996 and 3.58 % in 2010. In 2025, it is forecasted that only 0.001 % of mangroves forests will exist. The peat swamp forest had undergone similar pattern of growth. In 1974, 19.74 % of study area was covered by peat swamp. It reduced to 15.30 % in 1981, 9.50 % in 1988, 8.33 % in 1991, 6.76 % in 1996 and 4.34 % in 2010.

Figure 4 shows the changes in developed area. During 1996 until 2010, the fast growth of developing areas would be happened. Developed area showed tremendous changes from the 1970s. In 1974, the developed areas were calculated at 0.58 % which then increased to 0.81 % in 1988 and subsequently to 10.04 % in 2010. With current pattern, developed areas will be increased to 31.50 % in 2025. But the speed of growth because of different policies in this area is faster.

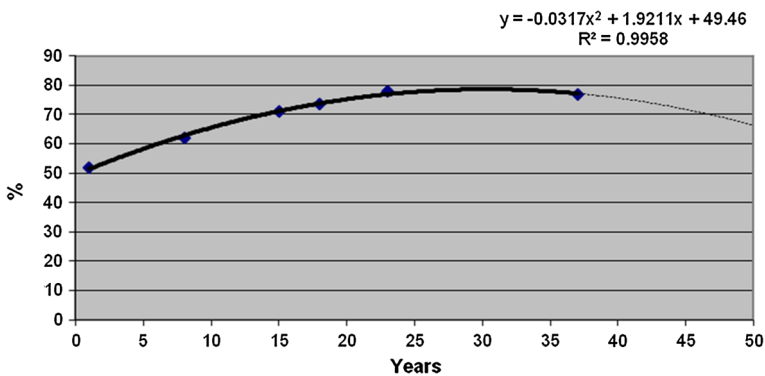


**Table 3** Forest changes analysis in Kuala Langat over 35 years (1974–2010)

GRIDCODE	1974 (ha)	%	1981 (ha)	%	1988 (ha)	%	1991 (ha)	%	1996 (ha)	%	2010 (ha)	%
Hill dipterocarp forest	0.64	0.02	0.62	0.02	0.49	0.01	0.35	0.01	0.32	0.01	0.18	0.004
Lowland forest	36.50	0.90	24.08	0.59	11.34	0.28	10.86	0.27	10.50	0.26	6.03	0.15
Mangrove forest	853.82	21.06	626.77	15.46	452.06	11.15	367.27	9.06	238.19	5.88	145.05	3.58
Peat swamp forest	800.11	19.74	620.09	15.30	385.13	9.50	337.57	8.33	274.13	6.76	176.13	4.34
Forest	1,691.07	41.71	1,271.55	31.37	849.02	20.94	716.05	17.66	523.14	12.90	327.39	8.08



**Fig. 4** Developed area change pattern in Kuala Langat district



**Fig. 5** Agricultural area change pattern in Kuala Langat district

The changes in agricultural areas have been shown in Fig. 5. The results show that agricultural area had increased in size from 51.85 % of total area in 1974–1977 to 89 % in 1996. But it decreased to 76.89 % in 2010. Agriculture is predicted to occupy some 63.6 % of total land area if this pattern of growth continued till 2025.

The change from agricultural to developed area will surely have an impact to ecological, sociological and economical conditions of Kuala Langat district in particular and Malaysia in general. The results of land use changes show that the primary driving forces for changes were economic and sociopolitical development. During the late 1970s and early 1980s, the development was under the implementation of NEP and the First Outline Perspective Plan (OPP1). Urban and regional development has begun to grow, and this was extended by the Second Malaysia Plan (1971–1975) with increased emphasis by the government on industrialization.

### 5 Discussion

An important goal in geo-environmental evaluation is to provide assistance to policy makers, planners and developers in planning the optimal development of an area while

simultaneously preserving the environment. The evaluation results can assist planners in making decisions on land use alternatives for specific land parcels (Dai et al. 2001). Multi-dimensional evaluation of coastal areas at different stage of planning and monitoring would assist decision makers to evaluate different decision options for future development (Pourebrahim et al. 2007). Digital change detection is the process of determining and/or describing changes in land use properties based on co-registered multi-temporal remote sensing data (Shalaby and Tateishi 2007). Information about change is necessary for updating land use maps and the management of natural resources (Xiaomei and Ronqing, 1999). A variety of applications of remote sensing data and spatial analysis for land use change detection have been made in various researches (Kuemmerle et al. 2009; Serra et al. 2008; Zondag and Borsboom 2009; Kanianska et al. 2014; Lambin and Meyfroidt 2010; Bürgi et al. 2004; Krausmann et al. 2003; Dekker et al. 2005; Ayad 2005; Van Eetvelde and Antrop 2004; Wilenius and Kurki 2012; Hersperger and Bürgi 2009; Vavclavik and Rogan 2009). They used different methods of analysis and different remote sensing data to explore changes in land uses. Accurate and up-to-date land cover change can help to understand and assess the environmental consequences of such changes (Giri et al. 2005). The information obtained by visiting sites on the ground and or extracting it from remotely sensed data.

According to Kondratieff, economies follow the path of long-term dynamic cycles or waves. A long wave lasts for 40–60 years and consists of a period of rapid economic growth, followed by stagnation or depression, creating the dominant socio technical landscape for the next wave (Wilenius and Kurki 2012).

The analysis of results of the land use change patterns over 35 years and the prediction of future changes have highlighted the problems of continuing the current pattern of growth. Based on results, in 2025, some serious environmental issues will surface, if the current development of land uses continued with this growth rate. In 2025, Malaysia will be a developed country with sustainable development planning and strategies, but the results of land use changes in the study area showed quite differently. The changes to urbanization and industrialization have some impacts on other land uses. These are reduction of forests, environmental sensitive areas and agricultural, resulting in increasing pollution and replacement of non-sustainable land uses. It requires an integrated plan for suitable and sustainable development, which should be emphasized urgently. However, it was heartening to note that the Malaysian Government were committed to a sustainable development plan, since the publication of the Sixth Malaysia plan (1991–1995) until the currently on going Ninth Malaysia plan (2006–2010), But realization of some of the strategies, plans and projects were hindered and hampered by several barriers and challenges of governance, participation, technology acquisition, economic, instruments, capacity building, etc.

From the information gained in the study of land use and land cover pattern changes, it is apparent that the primary driving forces are economic and sociopolitical development. While the spatial sciences would place elements such as distance and accessibility, as well as agglomeration and other location variables, the role of the government (and with it the social driving forces) cannot be downplayed. The patterns in Southeast Asian development as being state led and initiated, rather than a private sector endeavor supported or approved by the state (Hoogvelt 1977). The case in point is the development of Cyberjaya, Kuala Lumpur International Airport (KLIA) and the Federal Territory of Putrajaya which is located nearby to Kuala Langat district and Kuala Lumpur mega-urban region project.

This also includes the Sepang Goal Coast that located in this district where single storey resort style developments is constructed. Visually, it seems to fit the surroundings, though the feeling of an amphitheatre is felt, but the clearing of the jungle is apparent. There are elements of the Western architecture and landscaping, but the suitability to the surrounding is questionable, and it is almost as if it is aimed at impressing dignitaries and investors.

The mega projects that developed in the Sepang district (besides Kuala Langat) gives a major contribution to the development of this district. Together with the Cyberjaya intelligent city project, these efforts are capable of turning the entire region into a new city—as was attempted in Brasilia, during a much earlier time. Touted to be the hub of computer and multimedia technology, the structure plan projected some 570,000 population for the whole structure plan area 250,000 are expected to be within Putrajaya, another 240,000 in the incorporated area and the remaining 80,000 in Malay reserve lands. The structure plan also envisioned 127,000 jobs to be generated with 76,000 from the public sector and 58,900 from the private sector. Much of this perhaps will be jobs diverting from existing areas. It is also estimated that about 116,000 units of housing will be needed to house this new population. To add to this boom is the development of nearby Airport City at Bandar Baru Salak Tinggi, targeted not only to take over from Sepang as the District Administrative Center but also as an urban center with industries and new institutions.

Apart from this, the Sepang Formula 1 Circuit built 4 years ago, adjacent to KLIA, is very much active, has had a strong impact on the environment, particularly to the land use and land cover change, and to the people in Kuala Langat district. Other development projects expected to impact on the Kuala Langat coastal ecosystem that taken place includes;

1. The development of the north–south link highway connecting Kuala Lumpur with KLIA and the KL-Seremban highway.
2. The development of the South Klang Valley highway.
3. The proposed dedicated highway between Kuala Lumpur, Putrajaya and KLIA.
4. The development of the Express Rail Link connecting Kuala Lumpur, Putrajaya and KLIA.
5. The connecting system for the Light Rail Transit between Bukit Jalil and Putrajaya. The proposed coastal alternative route for Klang–Bukit Kemandul–Sepang–Lukut–Port Dickson–Tanjung Agas–Linggi–Melaka. The Bukit Nanas, Port Dickson waste disposal site.

The other primary driving force for land use change is the strong growth of construction industry in the early 1990s as which was hinged to the urbanization process, which up to the economic downturn of the late 1980s and 1990s had a major influence in driving investors to look for developable land, and the Kuala Langat, previously an agricultural region, provided the much needed asset. Conducive government policies and support of construction projects allowed the fast conversion of agricultural land (Mc Gee 2007).

## 6 Conclusion

The paradigm of change involving a movement from a rural to urban continuum with the restructuring of economic, social and political activities changes the area as non-agricultural activities. Mega urbanization brings deep structural changes that modify the economy and resources of the societies affected by the process such as massive loss of agricultural

lands to urban-based activities. This paper fulfills a holistic approach for exploring current patterns of growth to predict the growth pattern for the year 2025. The growth pattern was studied through land use change detection over 35 years, and the forecasting of 2025 was based on the assumption of the continued growth pattern. From the investigation of land use changes detection over 35 years and the follow-up predicted land use pattern of 2025, the current unsustainable pattern of growth was highlighted. This emphasizes the urgent need for a sustainable development plan to avoid the rapid land use changes. This approach has helped to find the weaknesses of the current plans.

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