

Shoreline Delineation and Land Reclamation Change Detection Using Landsat Image

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Abstract. This study is conducted on the usage of remote sensing images from several different years in order to analyze the changes of shoreline and land cover of the area. Remote sensing images used in this study are the data captured by the Landsat satellite. The images are projecting the land surface in 30 by 30 meter resolution and it is processed by the ENVI software. ENVI is able to change each digital number of the pixels on the images into specific value according to the applied model for classification in which could be used as an approach in calculating the area different classes based from the images itself. Therefore, using this method, the changes on the coastal area are possible to be determined. Analysis of the shoreline and land reclamation around the coastal area is integrated with the land use changes to determine its impact. The study shows that Batu Pahat area might have undergone land reclamation whereas in Pasir Gudang is experiencing substantial amount of erosion. Besides, the changes of land use in both areas were considered to be rapid and due to the results obtained from this study, the issues may be brought about for the local authority awareness action.

Keywords: Shoreline changes, land use, erosion, land reclamation.

1. Introduction

Coastal zone corresponds to the geomorphologic area on the part of the seashore in which the interaction between the marine and land parts begins in the form of complex ecological and resource systems composed of biotic and abiotic components coexisting and interacting with human communities and relevant socio-economic activities [1]. Its components may encompass river deltas, wetlands, coastal plains, beaches and dunes, mangrove forests, lagoons, reefs, and other coastal [2]. Coastal area around the world is a dynamic area with recurrently changing chemical, biological and geologic attributes which explain why they are frequently evolve over period.

Erosion is a naturally occurring process which is commonly made by rock and soil being released from the earth's surface over and over by water or wind before worn away [3]. The process is consistently slow and gradual that may take thousands of years but can be speeded up by human activities.

Thus, these makes the issue of environmental control on the development done in certain area to be vital in any academics discussion. There are many different kinds of erosion. One of the common examples is coastal erosion which is a serious problem that has potential to breed catastrophic impacts. Land use denotes the physical and biological cover of the surface of land. Land use changes is the conversion of a type of land to another type of land. Typically it is the result from government policies but they also may occur naturally such as a consequence of natural hazards or local agriculture practices. Land reclamation is an act of acquiring new land which is an example of land use changes. After large-scale undertakings in the past decades, reclamation activities in few countries were already subjected to strict control. Thus, presenting the newest monitoring discoveries of the involved area are crucial for a better understanding by the parties involved for them to decide their next line of action in order to maintain the safest environment for the communities.



2. Methodology

2.1 Data Collection

Data from Landsat were obtained from USGS Global Visualization Viewer (GloVis) website. The maximum cloud allowable on the images was limited to 10% only as cloud is a distraction in data analysis. Images from the year 1996, 2011 and 2015 were seized for the study area in Batu Pahat while in Pasir Gudang, year 1990, 2007 and 2014 were attained. The selected temporal data are from Landsat 5 and Landsat 8. To process image from Landsat, all the spectral bands were combined in only one image file by layer stacking tool. Next, three bands that give the most natural looking image were set on display which are band 3, 5 and 7 for Landsat 5 data and band 4, 5 and 6 for Landsat 7. All cloud that were present on some of the images were removed. Next off, classification was done on the image file to turn it into a land use map.

2.2 Land Use Map Creation

All land use maps generated from temporal data in both study areas undergone change detection analyses. Change detection statistics distinguished the contrasts between any pair of initial state and final state images. The change detection statistics produced a chart that displayed class-for-class image difference and also the land use changes. In order to analyze the coastal erosion and land reclamation, the changes in percentage of water and barren land are observed.

2.3 Land Use Maps Overlay

Land use map is a map that shows the types and intensities of different land uses in the particular area. Different colours were used to differentiate each classes in the land use maps. Blue was selected to represent the water body while green was for all kind of vegetation, includes plant with no chlorophyll. In addition, for barren land, orange colour was chosen to exhibited it whereas for urban and development, yellow color was picked.

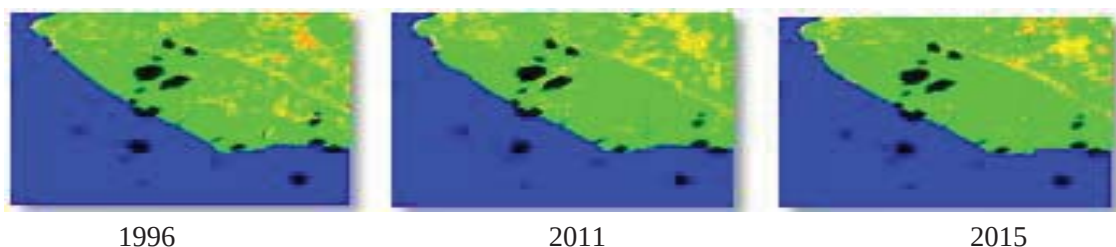


Figure 1. Land use maps of Batu Pahat.

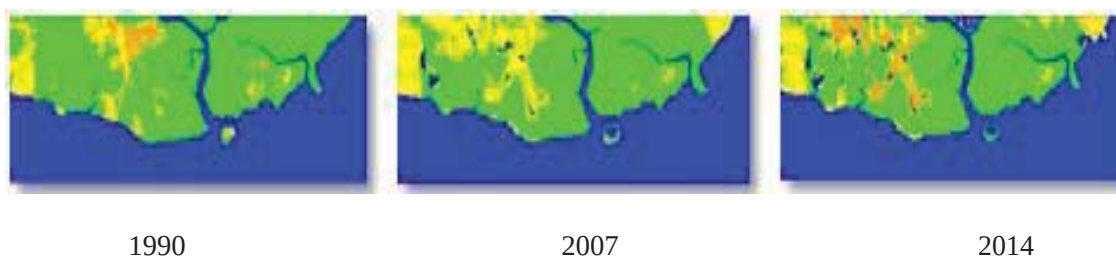


Figure 2. Land use maps of Pasir Gudang.

2.4 Change Detection Analysis

The resolution in every picture taken by Landsat satellite is 30 m by 30 m. When ENVI process the image by change detection, it will output the total pixel count for each class in the area therefore the area in the study areas can be determined by using the given equation (refer Eq 1).

$$\text{Area} = \text{pixel count} \times 30 \text{ m}^2 \times 30 \text{ m}^2 \quad (1)$$

3. Discussion and Analysis

Nowadays, growing number of worldwide sites have been affected by coastal erosion and land reclamation. Coastal ecosystems are one of the most impacted and altered regions worldwide because of the huge population that is concentrated along the coast [4]. On the other hand, land reclamation is the way to achieve more land. In recent decades, sea enclosing and land reclamation had become the best solution for the increasing demand of new land for living and development.

Urbanization, which mainly replaces permeable vegetated land surface with impervious surface areas, significantly alters the hydrologic fluxes of a drainage basin [5]. Physical alterations on shoreline or changes in coastal land use will affect coastal processes especially interfering adjacent marine communities [6]. The loss of biological diversity, erosion of beaches and loss of mangrove areas may influence ecosystem function, particularly shoreline stabilization. Humans receive valuable ecosystem services from coastal and estuarine ecosystems, including shoreline stabilization, protection of property, fisheries production and supporting biological diversity, but these services are lost with over-exploitation of coastal resources and loss of habitat [7]. Land Use Changes Analysis. On the year 1996 and 2011 in Batu Pahat study area, the water class grew by 0.4185 km² (0.904%) while the vegetation class risen to 0.8478 km² (2.398%) whereas the urban class increased by 1.4796 km² (19.154%). Barren land class is the only class that are declining by 2.7459 km² (77.437%). Whereas for the year 2011 and 2015, the water class decreased by 0.4761 km² (1.019%) whereas barren land aroused by 6.6915 km². Vegetation class is also declined by 0.1017 km² (0.281%) and urban class falling off by 6.1137 km² (66.422%).

Table 1. Pixel counts of Batu Pahat in 1996 to 2011.

	Water	Vegetation	Barren Land	Urban	Row Total	Class Total
Unclassified	0	0	0	0	0	3827
Water	51220	673	0	32	51925	51925
Vegetation	227	33164	1884	4942	40217	40217
Barren Land	0	293	414	182	889	889
Urban	13	5145	1642	3427	10227	10227
Class Total	51460	39275	3940	8583	0	0
Class Changes	240	6111	3526	5156	0	0
Image Difference	465	942	-3051	1644	0	0

Table 2. Pixel counts of Batu Pahat in 2011 to 2015.

	Water	Vegetation	Barren Land	Urban	Row Total	Class Total
Unclassified	0	0	0	0	0	3827
Water	51237	130	0	29	51396	51396
Vegetation	522	35636	149	3797	40104	40104
Barren Land	157	3823	107	4237	8324	8324
Urban	9	628	633	2164	3434	3434
Class Total	51925	40217	889	10227	0	0
Class Changes	688	4581	782	8063	0	0
Image Difference	-529	-113	7435	-6793	0	0

As for the year 1990 and 2007 in Pasir Gudang study area, the volume of the water in Pasir Gudang area between the year of 1990 to 2007 was boosted over 0.0774 km² (0.572%) while for the vegetation class, 1.0755 km² (10.082%) of area was lost.

In addition, the urban class was upsize by 2.2833 km² (151.825%). For the year 2007 and 2014, the water volume was up surged by 0.5130 km² (3.767%) and at the same time the vegetation class was withered by 0.5922 km² (6.174%). Moreover, urban class was also decreased by 1.5336 km² (40.494%).

Table 3. Pixel counts of Pasir Gudang in 1990 to 2007.

	Water	Vegetation	Urban	Row	Class Total
Unclassified	0	0	0	0	0
Water	14779	262	46	15087	15131
Vegetation	220	9511	402	10133	10658
Urban	46	2080	1223	3349	4208
Class Total	15045	11853	1671	0	0
Class Changes	266	2342	448	0	0
Image Difference	86	-1195	2537	0	0

Table 4. Pixel counts of Pasir Gudang in 2007 to 2014.

	Water	Vegetation	Urban	Row Total	Class Total
Unclassified	0	0	0	0	0
Water	15045	560	96	15701	15701
Vegetation	36	9475	489	10000	10000
Barren Land	1	157	1634	1792	1792
Urban	49	466	1989	2504	2504
Class Total	15131	10658	4208	0	0
Class Changes	86	1183	2219	0	0
Image Difference	570	-658	-1704	0	0

3.1 Shoreline Analysis

The size of the land use maps that were used in shoreline analysis were smaller as it were clipped so that only the water body from coastal area being processed in change detection. In the period from the year 1996 and 2011 in Batu Pahat, the region of water was deteriorated close to 0.1098 km² (3.519%) whereas the vegetation zone marked up by 0.1566 km² (5.303%). Besides, the amount of urban class was reduced too by 0.0414 km² (38.333%). While in between the year 2011 and 2015, the class of water descended by 0.2403 km² (7.982%) while the urban class also was ran low by 0.0567 km² (85.135%). In contrary, the vegetation class is the only class that was enlarged as it growth by 0.1143 km² (3.676%).

Table 5. Pixel counts of Batu Pahat (clipped) in 1996 to 2011.

	Water	Vegetation	Urban	Row	Class Total
Unclassified	0	0	0	0	98
Water	3284	61	0	3345	3345
Vegetation	183	3157	109	3449	3455
Urban	0	63	11	74	74
Class Total	3467	3281	120	0	0
Class Changes	183	124	109	0	0
Image Difference	-122	174	-46	0	0

Table 6. Pixel counts of Batu Pahat (clipped) in 2011 to 2015.

	Water	Vegetation	Urban	Row	Class Total
Unclassified	0	0	0	0	83
Water	3072	1	0	3073	3078
Vegetation	182	3361	29	3572	3582
Barren Land	91	92	35	218	218
Urban	0	1	10	11	11
Class Total	3345	3455	74	0	0
Class Changes	273	94	64	0	0
Image Difference	-267	127	-63	0	0

On the other hand, from the year 1990 to 2007 in Pasir Gudang, all the classes were increased. The water class had risen by 0.0117 km² (2.935%) and the vegetation class had increased by 0.0054 km² (1.049%) the same with urban class which was 0.0054 km² (12.5%). Furthermore, in between the year 2007 and 2014, the water class was roused by 0.0360 km² (8.772%) while the vegetation class was lessen by 0.0468 km² (8.997%). Similarly, the urban class was boosted over 0.0018 km² (3.704%).

Table 7. Pixel counts of Pasir Gudang (clipped) in 1990 to 2007.

	Water	Vegetation	Urban	Row Total	Class Total
Unclassified	0	0	0	0	0
Water	432	24	0	456	456
Vegetation	1	513	46	560	578
Urban	10	35	2	47	54
Class Total	443	572	48	0	0
Class Changes	11	59	46	0	0
Image Difference	13	6	6	0	0

Table 8. Pixel counts of Pasir Gudang (clipped) in 2007 to 2014

	Water	Vegetation	Urban	Row Total	Class Total
Unclassified	0	0	0	0	0
Water	456	27	13	496	496
Vegetation	0	515	11	526	526
Barren Land	0	10	0	10	10
Urban	0	26	30	56	56
Class Total	456	578	54	0	0
Class Changes	0	63	24	0	0
Image Difference	40	-52	2	0	0

3.2 Analysis of Coastal Erosion and Land Reclamation

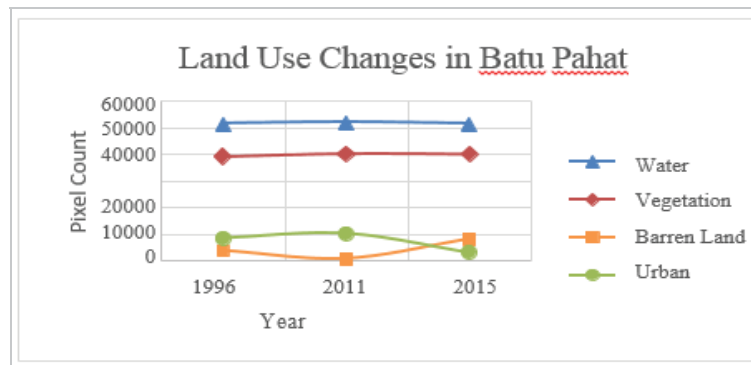


Figure 3. Graph of land use changes in Batu Pahat

In Batu Pahat study area, the water class was calmly increased from the year 1996 to 2011 but then it declined towards the year 2015 where the initial number of pixel from 51925 was lessened to 51396 which can be seen on Figure 3. Similarly, the urban class behaved the same way but towards the year 2015, it went down drastically. As for vegetation class, the pattern was also the same where the pixel count was accreted first before downturned after 2011 but it was indistinct. On the other hand, the barren land were the only that declined initially and started to went up following 2011. It can be conclude that the region in study area had undergone a rapid land use change since all classes were in uneven trend.

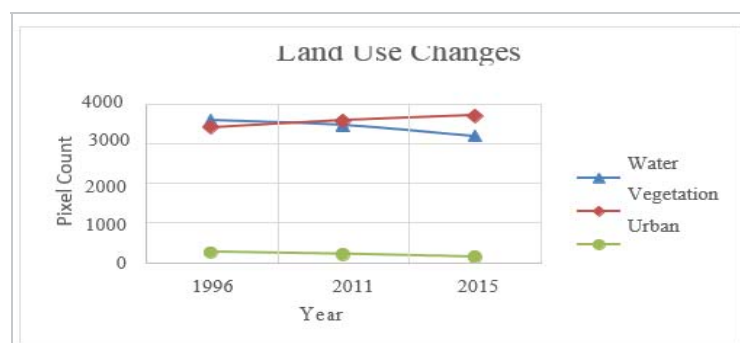


Figure 4. Graph of land use changes in Batu Pahat (clipped)

In shoreline analysis, the value of pixel count for vegetation was sequentially enlarged throughout the timeframe. The same patterned were followed by urban class. However, the vegetation class acted differently since the very beginning. The class progressively increased with the most prominent increment was from 2011 afterwards. The statistic were implying that this part of study area might undergone to land reclamation which can be analyzed from Figure 4.

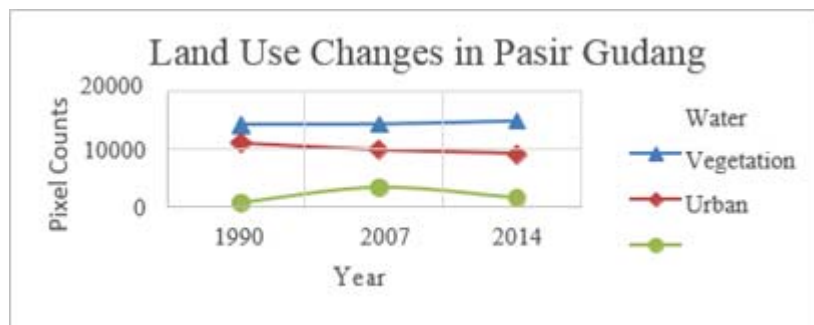


Figure 5. Graph of land use changes in Pasir Gudang

Based on Figure 5, in Pasir Gudang study area, the region of water continued to grow at a slow pace from the year 1990 until 2014. Whereas the vegetation class was descended gradually over the 24 year timeframe. Deviating from others, initially the urban class was risen progressively from 1990 to 2007 but it started to climb down thereafter. Based on these information, it seems like the region had undergone a rapid land use change too because the irregular pattern of urban growth and the continuous decrement of the vegetation class.



Figure 6. Graph of land use changes in Pasir Gudang (clipped)

As for its shoreline analysis, based from Figure 6, the urban class was risen continuously but at a very slow pace as if the changes was almost unnoticeable. These might implied that the development around the study area were carried out at a very slow speed. Furthermore, the pixel count for water went up crawlingly before 2007 but afterward it rouse dramatically. These might tell us that the region in study area was exposed to coastal erosion.

4. Discussion

In the study area, the change detection statistics proved that the area of water turned to vegetation and barren land are much more in comparison with the number of the other class that changed to water. At first only the coastal area near to the city was reclaimed but since there is erosion in adjacent area, land reclamation is extended throughout the area. The land reclamation rate is raised even more progressively after 2011. The purpose of it is maybe in order to prevent the flood as the last time it happened in Batu Pahat area was because the backwater from the sea into the Batu Pahat River. The reclamation is maybe delivered by the city council for future planning as reclamation to prevent erosion. Whereas in Pasir Gudang, the coastal erosion is much extensive. By referring to the change detection statistics, the area of water class kept growing throughout the interval as there is quite a vast portion of area from other class were exchanged with water class. The reason why erosion is vigorous in the area is most probably because of the hectic waterway. The region are bounded by two ports which are Pasir Gudang port and Tg. Langsat port. In fact, Pasir Gudang port is the biggest port in the southern of peninsular Malaysia.

In Batu Pahat study area, the rate of development is quite rapid. In the year 1996 to 2011 change detections statistics, there are 13.1% from total area of vegetation were swapped with urban land while 41.675% from area of barren land were exchanged with urban. Not to mention that there is 71.204% area of barren land were developed to urban between the year 2011 and 2015. The area of vegetation that is cleared to barren land between 2011 and 2015 was also vast which implies that there are more development in coming years. On the side, Pasir Gudang study area also shows a huge amount of development. In 1990 to 2007 change detection statistics, the percentage of the enlargement of urban area in the region are skyrocketed to 151.825%. Mainly the urbanization occurred in the study area are from the development of Tanjung Puteri Golf Resort and Tanjung Langsat port which mainly due to the development of three 18-hole of championship golf course built in the golf resort explaining the growing pixel count for vegetation and barren land classes in the area.

5. Accuracy Assessment.

With regard to accuracy assessment, a site verification was done in the study areas to confirm the accuracy of the land use map as the classification process might accumulate some errors. The site was verified by the aid of Global Positioning System (GPS) device. The coordinates from land use maps were extracted and it were compared with coordinates displayed by the GPS device on site in order to ensure each map produced are acceptable. For each study area, three random places were selected as checkpoints and for each checkpoints, all the classes available in vicinity area were inspected. For future study, few technique and methods should be taken into consideration such as by using seperability matrix or confusion matrix.

6. Conclusion

To conclude, the change detection done had successfully detected the changes between water body, vegetation, barren land and urban from medium spatial resolution remotely sense images provided by Landsat by performing a change detection analysis. From the results obtained, the rate of changes either impacted by the development processes or geomorphologic changes can be monitored based on the multi temporal images. This will help the organization and department involved in maintaining the sustainability of the study to reconstruct their plan of action in the upcoming future. In a nutshell, the land cover changes and also shoreline changes analyses were produced with a significant findings.

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