Flood-Induced River Disruption: Geomorphic Imprints and Topographic Effects in Kelantan River Catchment from Kemubu to Kuala Besar, Kelantan, Malaysia

Mohamad Muqtada Ali Khan, Nor Ashikin Shaari, Donny Adriansyah Bin Nazaruddin, Hafzan Eva Bt Mansoor

Abstract**—**Floods play a key role in landform evolution of an area. This process is likely to alter the topography of the earth's surface. The present study area, Kota Bharu is very prone to floods extends from upstream of Kelantan River near Kemubu to the downstream area near Kuala Besar. These flood events which occur every year in the study area exhibit a strong bearing on river morphological set-up. In the present study, three satellite imageries of different time periods have been used to manifest the post-flood landform changes. The pre-processing of the images such as subset, geometric corrections and atmospheric corrections were carried-out using ENVI 4.5 followed by the analysis processes. Twenty sets of cross sections were plotted using software Erdas 9.2, ERDAS and ArcGis 10 for the all three images. The results show a significant change in the length of the cross section which suggest that the geomorphological processes play a key role in carving and shaping the river banks during the floods.

Keywords**—**Flood Induced, Geomorphic imprints, Kelantan river, Malaysia.

I. Introduction

THE most intense geomorphological process at the river bank is the process of erosion. There is several methods to measure the river bank erosion and migration of channel including use of erosion pins, survey of the bench marked cross-sections and analysis of aerial photos [1]. The erosion process was started when raindrops dislodging soil particles and runoff water carries the dislodges particles to the river. The process of erosion is the most critical issue all over the world nowadays. In Tunisia, erosion by water has appears to be one of the chronic phenomenon whereas about 20 percent of the total land area were affected [2]. Sediment budget involved estimating the sediment contributed from three main process of erosion such as hillslope erosion, gully erosion and bank erosion. Through the evidense, it is identified that channel erosion is more important rather than hillslope erosion as a source of sediment in many Australian rivers [3]. Although bank erosion mainly occurs on outside of the river bends, sometimes it also occurs on straight sections and on the inside of the bends [4].

Erosion of the Kelantan river banks can be observed all along Kelantan River and its main tributaries. The main erosional processes are lateral cutting and undercutting which vary in intensity from one section of the bank to the other. The process of erosion is diffrent according to the shape of the river banks where concave banks suffer greater rate of erosion than convex banks. The river banks which contains dominantly clay are less intensively eroded than the section with loose clastic material. During bankfull discharge, the entire river banks is subjected to lateral erosion while during low stages only the wetted part of the bank are exposed to erosion when there is process of undercutting [5]. The geomorphology of Kelantan Delta is evidently formed from various physical and hydrological processes which act differently during different parts of the year and at different places within the delta. These processes are greatly influenced by the seasonal variations in the climatic conditions. The rate of development is accelerated during the northeast monsoon. While during the other months of the year, there is no major development perceived. The shape of the delta has been affected by the littoral beach drift [5].

II. Materials and Methods

A. Pre-Processing

The images used for this analysis is Spot 2 and Spot 5 supplied by Agency of Remote Sensing Malaysia (MACRES). It comprises three images of three different years (2004, 2011 and 2012) in Fig. 1. The pre-processing stage was conducted using software ENVI 4.5 and ERDAS 92. It includes the process to subset the images to reduce the images into desired area and it is important in order to smoother the further analysis. The next step of pre-processing is geometric corrections which were conducted to reproject the images so that they are lying on the same projection

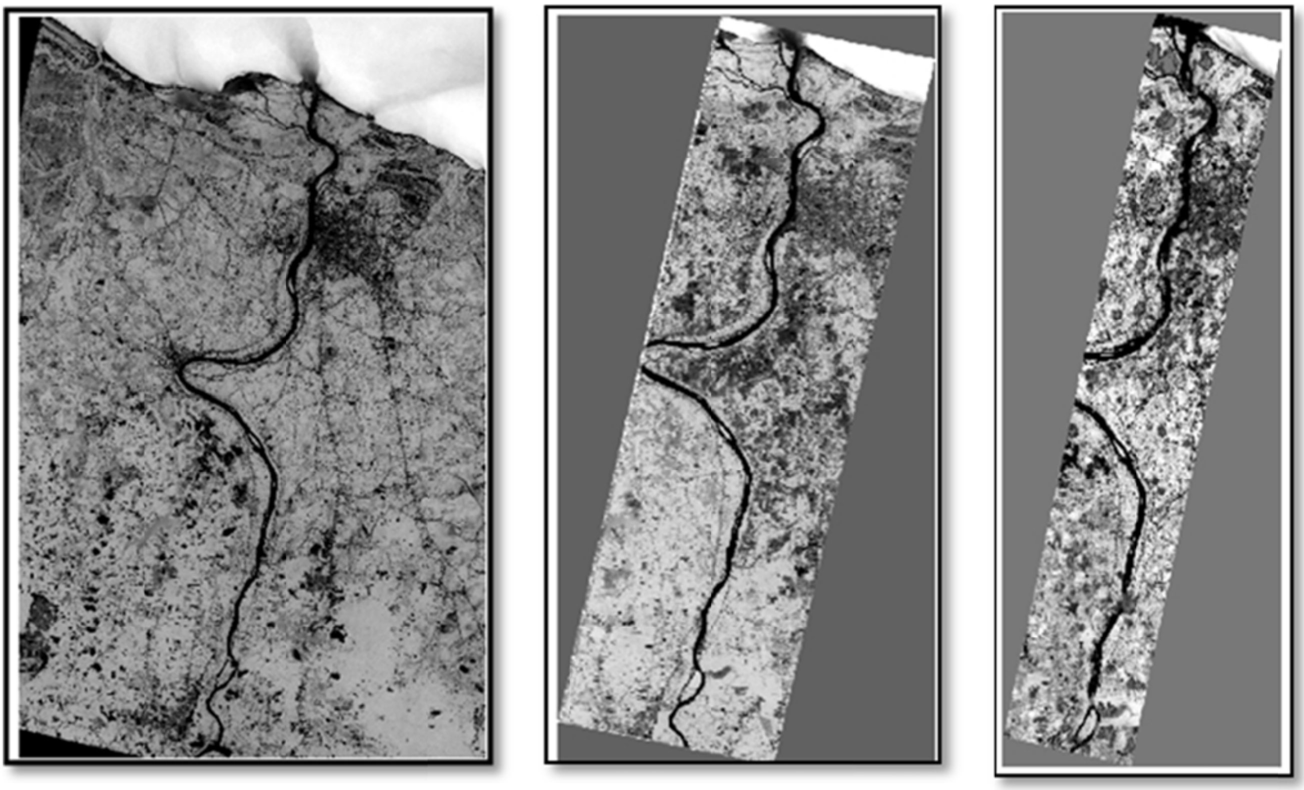
Mohammad Muqtada Ali Khan, Nor Ashikin Shaari, Donny Adriansyah Bin Nazaruddin and Hafzan Eva Bt Mansoor are with the Faculty of Earth Science, Universiti Malaysia Kelantan, Jeli Campus, Locked Bag No. 100, 17600 Jeli, Kelantan. Malaysia. (Corresponding author email: muqtadakhan@gmail.com).

B. Processing

The next step by using ERDAS 9.2 software is to produce Normalize Differentiate Vegetation Index (NDVI) data to differentiate between land with vegetation and water. In case of land with vegetation, the NDVI index will produce values between 0 to 1, while in case of river, the NDVI index will shows negative value.

C. Analyzing

After completed the pre-processing and processing the images, the next process is analyzing the data. The images were digitized using ArcGIS 10 and twenty cross sections were selected along Kelantan River which is from Kemubu to Kuala Besar and the differences in length between the three images were identified in Fig. 2, 3, 4.



(a) (b) (c)

Fig. 1 Process of subset the image in preprocessing step (a) Satellite image date: 08/09/2004 (b) Satellite image date: 10/07/2011 (c) Satellite image date: 23/02/2012, Supplying agency: Agency of remote sensing Malaysia (MACRES)

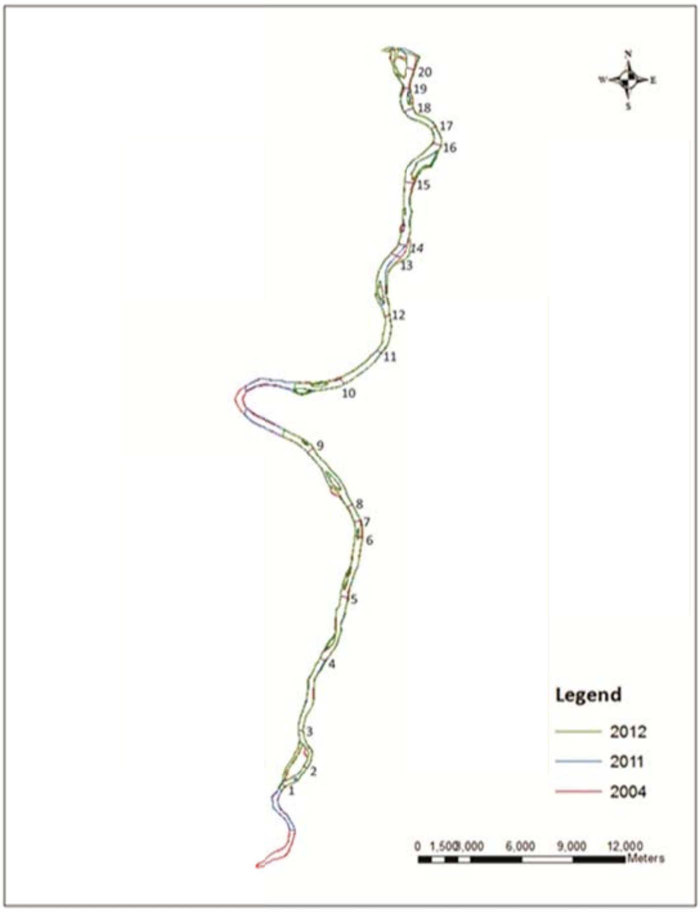


Fig. 2 Twenty cross section along Kelantan River from Kemubu to Kuala Besar

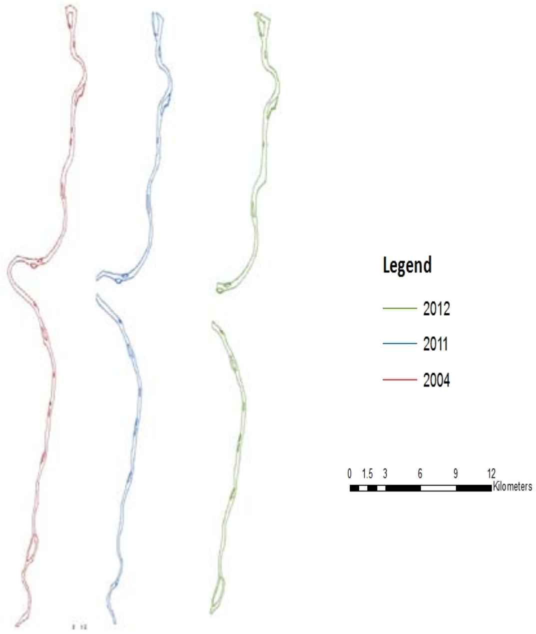


Fig. 3 Kelantan River changes for the year 2004, 2011 and 2012

(a) (b)

Fig. 4 Closer image to all the cross section (a) Cross section No 16, (b) Cross section No.17

III. Result and Discussion

A. Results

Twenty cross sections were plotted on the same coordinates for the three images and the lengths of the cross sections were measured in Fig. 2, 3. The results were shown in Table I. The differences in length for the three images were observed.

TABLE I
DIFFERENCE IN LENGTH (METER) FOR 20 SETS OF CROSS SECTION ALONG SUNGAI KELANTAN FROM KEMUBU TO KUALA BESAR FOR YEAR 2004, 2011 AND 2012

Cross section no.	2004	2011	2012
1	290.27	288.57	298.93
2	232.4	235.97	238.36
3	268.5	267.96	275.51
4	446.99	438.97	447.69
5	390.35	395.28	403.68
6	387.55	388.09	395.68
7	401.96	422.94	439.98
8	349.97	349.59	348.67
9	351.17	349.44	353.09
10	373.08	388.45	390.14
11	471.51	472.76	477.51
12	551.24	542.66	543.35
13	549.18	509.53	510.69
14	350.89	328.82	329.91
15	848.86	859.28	861.22
16	459.17	460.68	466.08
17	491.86	513.59	522.1
18	293.38	296.3	370.36
19	417.68	449.81	464.8
20	379.05	397.51	395.86

From the results in Table I, it shows that the length is changing for the three image for all twenty cross section plotted.

B. Discussion

According to the analysis in Table II, twelve cross sections show increase in length between year 2004 and 2011 while the other shows decreasing. Between the year 2011 and 2012, almost all the cross sections show increasing with 17 of them show increasing in the length of the river, while three of the cross sections show decreasing. The highest increasing in the length of the cross section is cross section no.19 where 32.13 meter of the length increased between the year 2004 and 2011. It is located upstream of the river near South China Sea. Another highest length is cross section no.17 where the length is 21.73 between the year 2004 and 2011.

From the results, most of the length of the river banks is increasing. It indicates that the geomorphological process such as erosion, weathering were happened at the river bank and the sediment resulted from the process were transported and deposited and the process were most extensive during heavy rainfall and flood event. The geomorphological process happened were differs according to the shape of the river where the concave shape banks were most affected and changes rather than convex shape. This difference were clearly shown on cross section no. 16 and cross section no.17. The convex shape can be seen in cross section no 16, while the concave shape can be seen on cross section no. 17. The cross section no. 17 shows a higher length than cross section no. 16 in Fig. 3, 4.

TABLE II
THE DIFFERENCE BETWEEN THE THREE YEARS

Cross section	2004	2004-2011 difference	2011	2011-2012 difference	2012
1	290.27	1.7	288.57	10.36	298.93
2	232.4	3.57	235.97	2.39	238.36
3	268.5	0.54	267.96	7.55	275.51
4	446.99	8.02	438.97	8.72	447.69
5	390.35	4.93	395.28	8.4	403.68
6	387.55	0.54	388.09	7.59	395.68
7	401.96	20.98	422.94	17.04	439.98
8	349.97	0.38	349.59	0.92	348.67
9	351.17	1.73	349.44	3.65	353.09
10	373.08	15.37	388.45	1.69	390.14
11	471.51	1.25	472.76	4.75	477.51
12	551.24	8.58	542.66	0.69	543.35
13	549.18	39.65	509.53	1.16	510.69
14	350.89	22.07	328.82	1.09	329.91
15	848.86	10.42	859.28	1.94	861.22
16	459.17	1.51	460.68	5.4	466.08
17	491.86	21.73	513.59	8.51	522.1
18	293.38	2.92	296.3	74.06	370.36
19	417.68	32.13	449.81	14.99	464.8
20	379.05	18.46	397.51	1.65	395.86

Increasing ecreasing

The changes in the length of the Kelantan River also signifies the amount of sediment transported to the river. The high amount of changes in the length that reach up to 32.13 meter in cross section no.19 shows that such a high amount of sediment were lost from the year 2004 to 2011 and the sediments were transported to the river bed. This sediment deposited at the river bed and decrease the depth of the river thus reduced the area of the river. Reduction in the river depth will increase the risk of flood disaster to occur as it decrease the area for runoff water to occupies.

IV. Conclusion

The analysis of images show that the geomorphological process has extensively occur at Kelantan River banks within the study area that modified the river pattern as shown in the present study. This change also affected the flood conditions in the study area where it increased the amount of sediment deposited at the river bed thus reducing the depth of the river. Reduction in the river depth will increase the risk of flood disaster to occur as it decrease the area for runoff water to occupies.

Acknowledgment

The financial assistance provided by short term research grant project (Ac No.R/SGJP/A08.00/00644A/001/2012/000080), Universiti Malaysia Kelantan, is gratefully acknowledged. The author are also thankful to all staff of lab, Universiti Malaysia Kelanatan, Campus Jeli for providing facilities to carry out this work.

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