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Analysis of River Channel Change Using Remote Sensing Images at Kelantan River Basin

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Abstract. This study presents the utilities of remote sensing technique for analysis of river channel change using remote sensing images at Kelantan River Basin. Understanding river channel change is a key component in developing ecologically friendly and long-term fluvial projects, as well as a way to reduce maintenance costs. The project's study and conclusions will aid in determining how to recognise probable morphological change in river channels. Remote sensing is one of the effective methods for water quality monitoring through image analysis of study area. These tools provide valid means of studying river channelchanges. In this study, river channel changes are monitored and quantified by using remote sensing and GIS in Kelantan River. This study focus on four interval years between year 1988 until year 2021 by using Landsat satellite images of 30 m spatial resolution. Landsat Thematic Mapper (TM) 5 images of three different years which are 1988, 1999 and 2010, and Landsat 8 of OLI/TIRS year 2021 were compared. The quantity of accretion and erosion was assessed using parcel-based geoprocessing in a GIS system. The locations are labelled with the year they were created. The area of each year is changing by study period of time for all four interval years 1988, 1999, 2010, and 2021 for research area 1 and 2. The results prove that the river channel in Kelantan is altering, where between 1988 and 2021, the Kelantan River's course has changed significantly. The years 2010 to 2021 are the most severely affected by erosion as a result of the flood in 2014 on the Kelantan River.

1. Introduction

A river is a natural watercourse that flows towards an ocean, a lake, the sea, or another river, and is generally freshwater [1]. A river channel is a body of water, in this example a river, that runs deeper in the centre and follows a route physically bounded by the river bed and/or banks. Although "channel" and "strait" are synonyms, "channel" typically refers to a smaller body of water (fresh, salt, or brackish) that runs along a channel and is joined by two larger bodies of water (the sea). Channel is the deepest portion of the river and the part that continues to flow. Rivers are alive and well. They willalter course over time because to natural erosion and sedimentation processes. Different humanactions, on the other hand, can speed up these processes. This might have a big influence on local communities. Water flow shapes the morphology of a river channel. Channels alter in various waysdue to erosion and deposition, both of which are influenced by catchment factors [2].

The major source of erosion in the Kelantan River basin is deforestation and planting [3]. As a result of the soil erosion, the main river and its riverbed are always muddy. Erosion deposits silt in rivers, which eventually flow into the open sea. Increasing silt concentration in water bodies can cause environmental harm, hence monitoring water quality is critical for Delta Kelantan management. This monitoring might lead to improved water resource management and the protection of the delta zone from disruptions.

In numerous decades, scientists, researchers, and aquatic resource managers have used the traditional approach of spot sampling to monitor water quality. Although this approach can provide reliable measurements of water quality indicators, such a study is time-consuming and costly. Through the analysis of digital pictures, remote sensing has become a useful approach for water quality monitoring. Remote sensing overcomes the challenges of broad coverage areas with high temporal frequency. Monitoring water quality with a remote sensing technology can deliver a satisfactory result at a lower cost [3]

2. Materials and Method

2.1. Study area

According to [3], the Kelantan Delta is located in northeastern West Malaysia, between latitudes 6° 10'N and 102° 15'E. This study located at Kelantan River, between latitudes 4° 40' and 6° 12' north, and longitudes 101° 20' and 102° 20' east, in Peninsular Malaysia's north eastern region. Two training site sample at Kelantan River were choose as study area 1 and 2 for four interval years which is 1988, 1999, 2010, and 2021.

2.2. Methodology

The study makes use of Landsat images for year 1988, 1999, 2010, and 2021 from the Kelantan River Basin. Google maps are created using open source (Google Earth Pro) software, which incorporates global spatial pictures gathered by remote sensing of the earth's surface, as well as image processing for visual interpretation. Images are cropped using this programme. Secondary data was received from the United States Geological Survey (USGS) Agency (https://www.usgs.gov/) and included multi- temporal Landsat imageries with a resolution of 30 m. Landsat 5 TM data for the years 1988, 1999,and 2010 are included. While photos from landsat 8 (OLI) are year 2021. The Kelantan map was also utilised to extract a shape file for the research area (Figure 1 and Figure 2). Landsat images were taken from the United States Geological Survey's (USGS.gov) repository, while the Kelantan map was obtained using Google Earth Pro software.

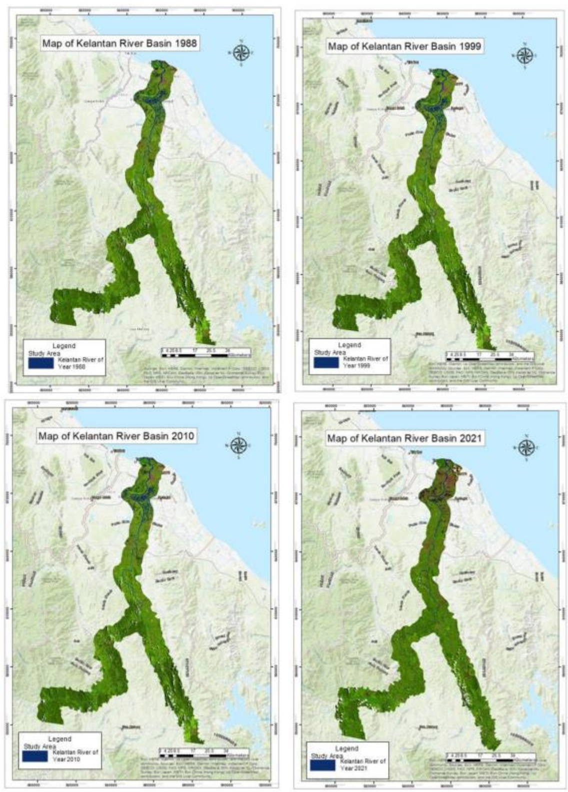

Figure 1. Map of Kelantan River Basin

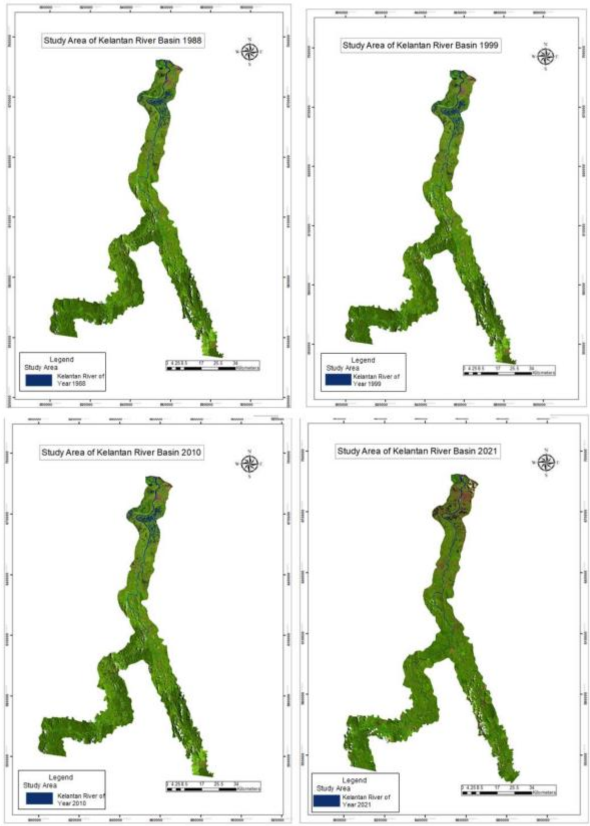

Figure 2. Study Area of Kelantan River Basin

2.3. Image processing and classification

For Landsat TM 5 and Landsat 8 OLI TIRS, the pictures were layer stacked using a composite of band 4- blue, band 2- red, and band 3- green. For consistency and to adjust for radiometric and geometric flaws, the pictures were projected to the Universal Traverse Mercator (UTM) coordinate system Zone 31 N using the World Geodetic System (WGS) 1984 datum. The modifications were made by converting the raw Landsat pictures' original digital number (DN) to top-of-atmosphere reflectance values. Two training sample sites were chosen from each study area of the Kelantan River and classified to produce extract water body Kelantan River study area maps for the study periods using the unsupervised classification approach.

2.4. Bank erosion mapping

Using the raster to polygon method in ArcGIS, the provided photos of the Kelantan River in 1988, 1999, 2010, and 2021 were automatically transformed from raster to polygon format to establish the specified location of interest. Then a new data frame was added to categorise research areas 1 and 2 as 1988-1999, 1999-2010, and 2010-2021, resulting in a map showing 1988-1999, 1999-2010, and 2010- 2021 for study area 1 and 2. The images of each year in each category, which are 1988-1999, 1999- 2010, and 2010-2021, were layered and intersected in ArcGIS under geoprocessing to determine the changes in the river channel over time. This altered section of the river is vectorized in GIS and plotted throughout the field activity in the research region.

2.5. River channel change detection

The research region's advanced remote sensing data (Google Image) depicting current circumstances. The shifting position of the river from the real flow line is made obvious by this database vectorision in GIS software. Both the Raster data base (Land satellite and Google picture) vecterision on distinct layers across unique scale and projections indicates the variations in stream from the true baseline, which is referred to as 'River shifting'. This shift is recognised using a variety of data sources and field activities, as evidenced by mapping calculations and a thematic base map with quantitative data creation [4].

3. Results and Discussion

3.1. Parcel-based geo-processing

The quantity of accretion and erosion was assessed using parcel-based geoprocessing in a GIS system. By digitising coastal rivers from Landsat images in ArcGIS 10.3, erosion and accretion areas were estimated. The coastal study region is covered by four Landsat sceneries per year. Landsat-5 TM (30 m) for 1988, 1999, and 2010 and Landsat-8 OLI (30 m) for 2022 were the best available and selected pictures. The water bodies for research areas 1 and 2 at Kelantan River were then digitised in polygon shape files for each year. To create polygon (area) shape files, great care was taken to get an exact river water body. The erosion accretion shape files were then created by utilising the 'Intersect' tool in ArcGIS 10.3 to compute a geometric intersect of polygon shape files from two consecutive years.After validating each polygon for erosion and accretion, the shape files were completed. Results of erosion accretion for 1988-1999, 1999-2010, 2010-2021 for study area 1 and 2 are shown in Figure 3 and Figure 4, respectively.

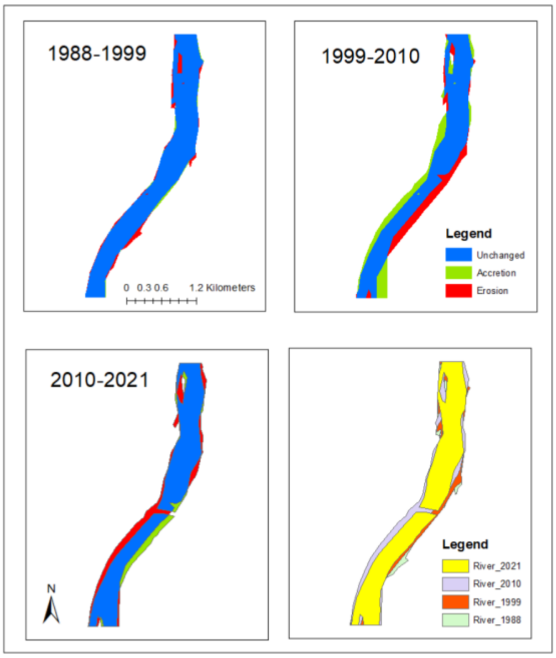

Figure 3. Results of erosion accretion for study area 1 for 1988-1999,1999-2010, 2010-2021

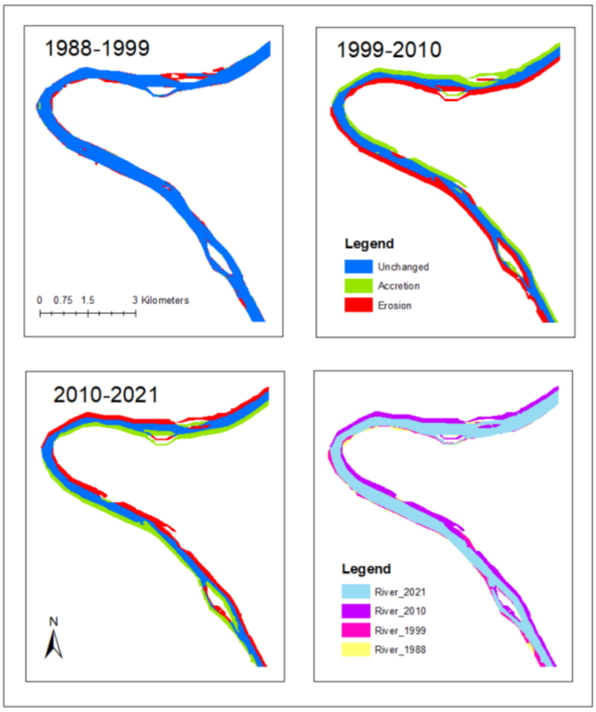

Figure 4. Results of erosion accretion for study area 2 for 1988-1999,1999-2010, 2010-2021

3.2. Analysis of river channel changing

Table 1 presents the outcomes of the river analysis of research area 1's channel. Table 1 shows that the unchanging areas from 1988-1999 are 188.4364 (ha), 159.8430 (ha) for the years 1999-2010, and 163.6779 (ha) for the 2010-2021 year. The average annual rate of erosion between 1988 and 1999 was 14.9505 ha, 31.6672 ha from 1999 to 2010 and 326.4510 ha from 2010 to 2021. From 1988 to 1999, there was an accretion of 3.0738 ha, 40.2215 ha from 1999 to 2021, and 17.2783 from 2010 to 2021.

Table 1. Change of river channel study area 1

Year	Previous 11 Years (ha)	Next 11 Years (ha)	Unchanged (ha)	Erosion (ha)	Accretion (ha)
1988-1999	203.3869	191.5102	188.4364	14.9505	3.0738
1999-2010	191.5102	200.0644	159.8430	31.6672	40.2215
2010-2021	200.0644	180.9561	163.6779	236.4510	17.2783

The results of river analysis of the channel of study area 2 are presented in Table 2. Table 2 shows the unchanged area for 1988-1999 is 679.4583 (ha), 389.162 (ha) for the years 1999-2010, and 374.8492 (ha) for the 2010-2021 year. The erosion was 65.3079 ha between 1988 and 1999, 295.2516 ha between 1999 and 2010, and 245.0108 ha between 2010 and 2021. The accretion from 1988 to 1999 is 4.9554 ha, 230.6979 ha from 1999 to 2021, and 244.4310 ha from 2010 to 2021.

Table 2. Change of river channel study area 2

Year	Previous 11 Years (ha)	Next 11 Years (ha)	Unchanged (ha)	Erosion (ha)	Accretion (ha)
1988-1999	203.3869	191.5102	188.4364	14.9505	3.0738
1999-2010	191.5102	200.0644	159.8430	31.6672	40.2215
2010-2021	200.0644	180.9561	163.6779	236.4510	17.2783

3.3. River channel change detection

Figure 5 indicates that the largest erosion occurred from 2010 to 2021, compared to 1988 to 1999 and 1999 to 2010. This is due to the fact that the monsoon flood of December 2014 to January 2015 was one of the most destructive floods to hit Malaysia in recent decades, with over 100,000 flood victims forced to flee their homes. The flood in Kelantan was mostly caused by continuous heavy rain from December 21 to December 23, 2014, which was comparable to more than 60 days of rainfall, causing the river's water level to exceed that of previous floods in 1967 and 2004. [5]. Unchanged area of year 1988-1999 show the highest compared to 1999-2010 and 2010-2021. Linking river behaviour and drainage basin evolution to environmental change, particularly the effects of climatic variability, tectonics, and human activity on runoff and sediment delivery [6], the result proves by showing 1988-1999 is the lowest accretion and erosion between 1999-2010 and 2010-2021. The highest accretion occur in 1999-2010 compared to 2010-2021 and 1988-1999.

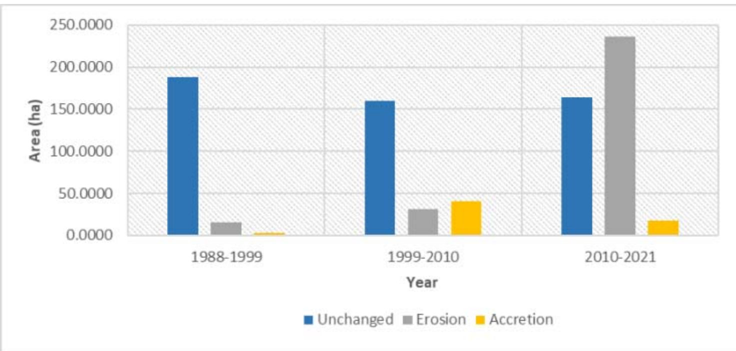

Figure 5. Graph of Area (ha) river channel for year 1988, 1999, 2010, 2021 (study area 1)

The river changing were observed in the Graph of Area (ha) river channel for the years 1988-1999, 1999-2010, and 2010-2021 (study area 2) revealed that the decrease in the proportion of unchanged area in all three years 1988-1999, 1999-2010, and 2010-2021 accounted for the increase in accretion and erosion in those years. Zhou et. al (2011) confirmed a decrease in water body as a result of increase in deposition within a channel reach. Sediment deposits in rivers can alter the flow of water and reduce water depth, which makes navigation and recreational use more difficult. soil particles that settle at thebottom of a body of water. Sediment can come from soil erosion or from the decomposition of plants and animals. This proves why the unchanged area of 1988-1999 is the highest and the lowest erosion and accretion occurred compared to 1999-2010 and 2010-2021.

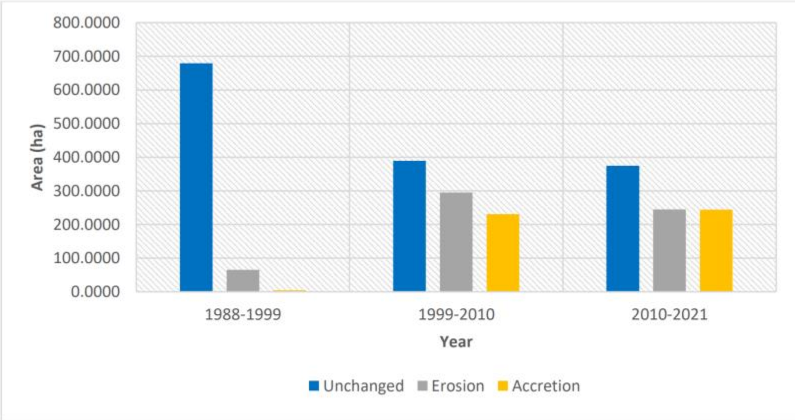

Figure 6. Graph of Area (ha) river channel for year 1988, 1999, 2010, 2021 (study area 2)

4. Conclusion

In this study, an attempt is made to combine analogue and current digital data sources to identify river bank erosion, accretion, and channel shifting. Finding the river channel changing owing to bank erosion and accretion using this year-by-year data base. The different time actual positions of the river were shown in a vector database created from Landsat image data and Google maps of the research region. The Kelantan River has been displaced from its original baseline course, according to this mapping. High bank erosion was discovered in the research region, which resulted in the river altering course. Throughout this case study, it is demonstrated that river alterations are caused by a variety of natural and man-made occurrences. At the micro level, it has examined by diverse analogue and advanced digital data. Finally, despite certain alterations, topographical remote sensing data and GIS studies can benefit in the advancement of detection and other fields of fluvial sciences.

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