# FLUVIAL – TIDAL TRANSITIONAL CHANGES OF SITTAUNG RIVER IN MYANMAR: EMPHASIS ON POINT-BAR GEOMORPHOLOGICAL CHARACTERS OF PAZUMYAUNG, MADAUK AND KYAIKTO AREAS

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## Abstract

Three areas were selected and observed for this study which includes the Pazumyaung area, Madauk area and Kyaikto area along Sittaung River in Myanmar. Geomorphologic measurements, samples collection and outcrop measurements were carried out during dry season when water level was low and most of point bars were exposed. Geomorphological characters of Sittaung River were determined based on UTM maps, Google earth maps and Landsat images by using geospatial analysis, studying of scroll bar pattern and observing sinuosity and width of the river. The distinguishing of both surface sediment distribution and sedimentary structures of point bar were provided for the geomorphological characters. By the analytical data, the fluvial dominated zone is Pazumyaung area, tidal and fluvial transitional zone is Madauk area and tidal dominated zone is Kyaikto area. The water body changes and channel migration of Sittaung River are analyzed by using density slice on ENVI 4.7. South of Madauk area and Kyeikto area are highly environmentally changed areas where natural disasters such as river flooding and flooding related environmental problems in Sittaung River and its environs are likely to occur.

**Key words:** Geomorphological characters, zone, Sittaung River

## Introduction

The Sittaung river basin is located in central-south Myanmar and contains the Sittaung River. Twenty three major tributaries flow into the Sittaung River. The river is navigable for 40 km year-round and for 90 km during three rainy months. With distinct seasonality in river discharge and macrotidal range, the river has extensive fluvial-tidal transition zone from estuary to 150 km inland. This field study was conducted to understand the

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characteristics of point bar architecture of Sittaung River along fluvial-tidal transition zone.

## Location of Study Area

The study area is located in the eastern part of Sagaing Fault. It lies between Latitude 17˚15′ N to 18˚ 00′ N and Longitudes 96˚ 45′ E to 97˚ 00′ E. The study area falls in the topographic maps of 1796 (13, 14, 15) respectively. The study area is situated in the Central lowlands of Myanmar drained by Sittaung River which forms main study for this research work. Three areas were selected and visited for this field study, which includes Pazumyaung area, Madduk area and Kyaikto area along the Sittaung River. (Figure.1)

## Purposes of Study Area

The main purposes of this study are observation and determination for geomorphological characters, geomorphological zones and natural changes of Sittaung River in Myanmar by using the images geospatial analysis and geological data.

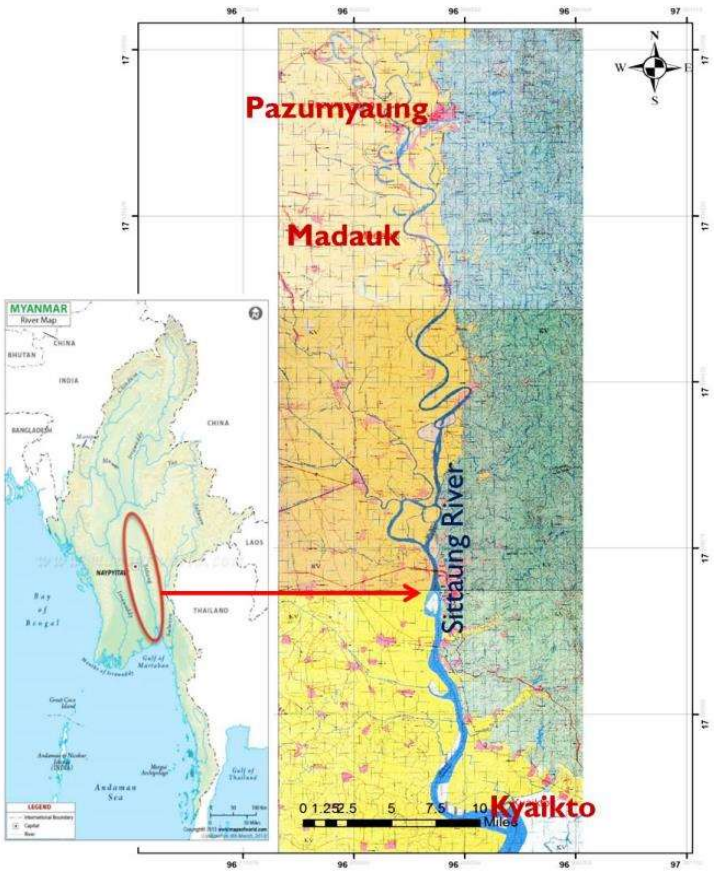


**Figure 1.** Location Map of Study Area

## Previous work

In 2015, Field party of Geology Department, Dagon University and Seoul National University studied on the Geomorphological characteristics of channels in the fluvial-tidal transition zone of Sittaung River, Myanmar. In 2015, Max van Rest, Civil Engineering at Technical University of Delft studied on the Monitoring of the Sittaung River; including bathymetry and floodplains. In 2016, Takao Yamashita and Htay Aung, Graduate School for International Development and Cooperation, Hiroshima University investigated on the Projection and Historical Analysis of Hydrological Circulation in Sittaung River Basin, Myanmar.

## Background Geology

Sittaung River drains the Central Basin and lowlands, lying between the Pegu Yoma and Shan Plateau with trend structurally parallel to Sagaing Fault. Sittaung River basin is overlain by the Pleistocene sediments such as soft sandstones, shale, clays and alluvial deposits. Sandstone is rather permeable where clay and silt show a lower value to the permeability of the soil. Pegu Yoma including the Pegu Group and Irrawaddy Formation are well-exposed to the west of Sittaung River. Shan Plateau including the Mogok Metamorphic Belt, Central Granitoid Belt, Taungnyo and Lebyin Formations and Plateau limestone and Loi-an Group are well-exposed to the east of Sittaung River. See Figure (2)

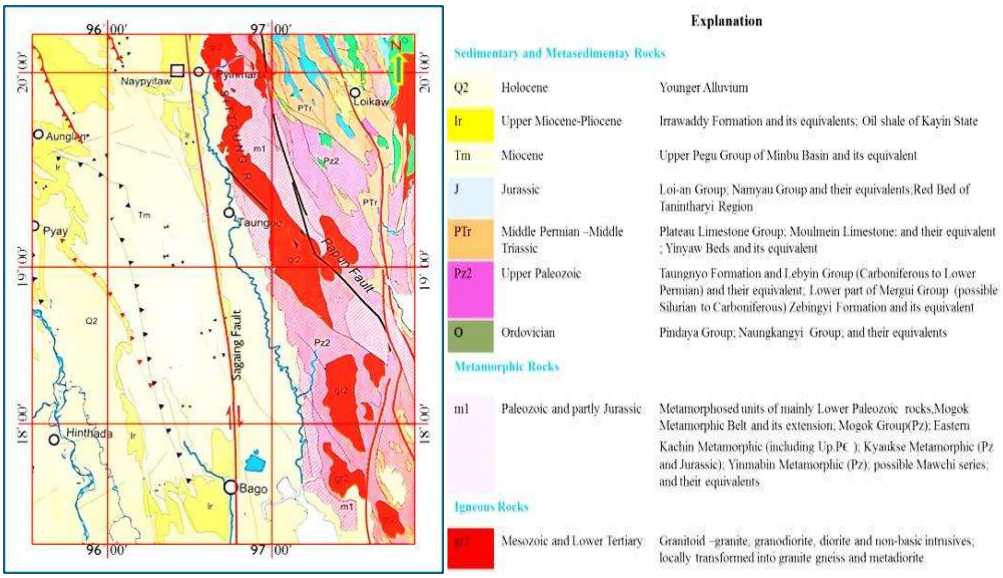


**Figure 2.** Regional Geological Map of Study Area (After MGS,2014)

## Method of Study

Three areas were selected and visited for this field study, which included Pazumyaung area, Madduk area and Kyaikto area along the Sittaung River. At each station, we conducted geomorphologic measurements of point bars and dunes on the bars, can-coring of unconsolidated sediments, and outcrop measurements along the cutbanks. The study of project research is

based on the UTM maps 2000 and the Landsat images 132_48N of 2000, 2005, 2010,2015. The Geospatial analysis software such as Global Mapper 15, ENVI 4.7, Arc Map 10.1, Microsoft Excel 2010 and SPSS are used for this project work.

The water body changes and coast line variation of Sittaung River were determined by the density Slice on ENVI 4.7. Choosing the Band 6 is suitable for Density Slice. The Slice range is 6 to 27 Red. The band combination of Band 685 and Band 654 (RGB) of Landsat image 2015(132_48N) displayed the morphological zonation of Sittaung River. The shape files of Sittaung River were successively analyzed on Arc Map 10.1 such as image digitizing and constructed the personal geodatabase that involved the Latitude and Longitude, sedimentary grain size and sedimentary structures. And the comparison of shape file of Sittaung River, Interpolation of sedimentary grain size distribution and Interpolated Line of morphological profiles of Sittaung River were conducted on Arc Map 10.1. The illustrated maps were created by using the layout view of Arc Map 10.1. Therefore, this project is the accomplishment of cartography, remote sensing interpretation, surveying, operational, statistical interpretation and analysis.

## Results and Findings

### Geomorphological Characters and Geomorphological Zones of Sittaung River

The Geomorphological Characters and Geomorphological Zones of the river were determined based on UTM maps, Google earth maps and Landsat images by using geospatial analysis, studying of sinuosity and width and scroll bar pattern of the river. The distinguishing of both surface sediment distribution and sedimentary structures of point bar were provided for the classification of geomorphological characters and zones.

### Geospatial analysis

There are three morphological zones that can be classified by using the band combination of RGB, band 685 and band 654 on ENVI 4.7. The gradual change of one specific zone to another can be seen in the colour change along

the river of the image. The Pazumyaung area is Zone 1, Madauk area is Zone 2 and Kyaikto area is Zone 3. See Figure (3.A)

**Surface sediment distributionanalysis**

The transported or deposited stream sediment is gradually decreased in grain size to the river mouth. There are three specific zones and areas which are fluvial dominated Pazumyaung area, zone1shows coarse sand, tidal and fluvial transitional Madauk area, zone 2 indicates medium sand and tidal dominated Kyaikto area, zone 3displaysvery fine sand and mud. See Figure (3.B)

**Sedimentary Facies analysis**

In the cores from Pazumyaung, tabular cross-bedded medium to coarse sands are dominant. The cross-beddings are unidirectional and have tangential contacts. Bioturbation is rare.These characters show fluvial dominated zone.

The cores from Madauk also show dominantly unidirectional, trough cross-bedded medium sands at lower part, and laminated muds at upper part.Laminated mudis slightly bioturbated and contains tidal laminations. These characters indicate tidal and fluvial transitional zone.

The cores from Kyaikto display inclined heterolithic stratification in which sands and muds are rhythmically laminated. Tidal cycles such as diurnal inequality and neap-spring tidal cycles are well preserved. These characters designate as tidal dominated zone. See Figure (3.C)

**Sinuosity and width analysis**

Sinuosity and width of Sittaung River were measured from satellite images. Based on the sinuosity and width, Sittaung River is morphologically divided into three zones.

The fluvial dominated zone (zone 1) is narrow with consistent width and intermediate sinuosity (<2). Tide-influenced and fluvial dominated zone (zone 2) shows downstream increase of width and greater sinuosity (>3). Tide dominated zone (zone 3) is wide with funnel-shaped width and low sinuosity (~ 1). The boundary between zone 2 and zone 3 is characterized by the greatest sinuosity. See Figure (4)

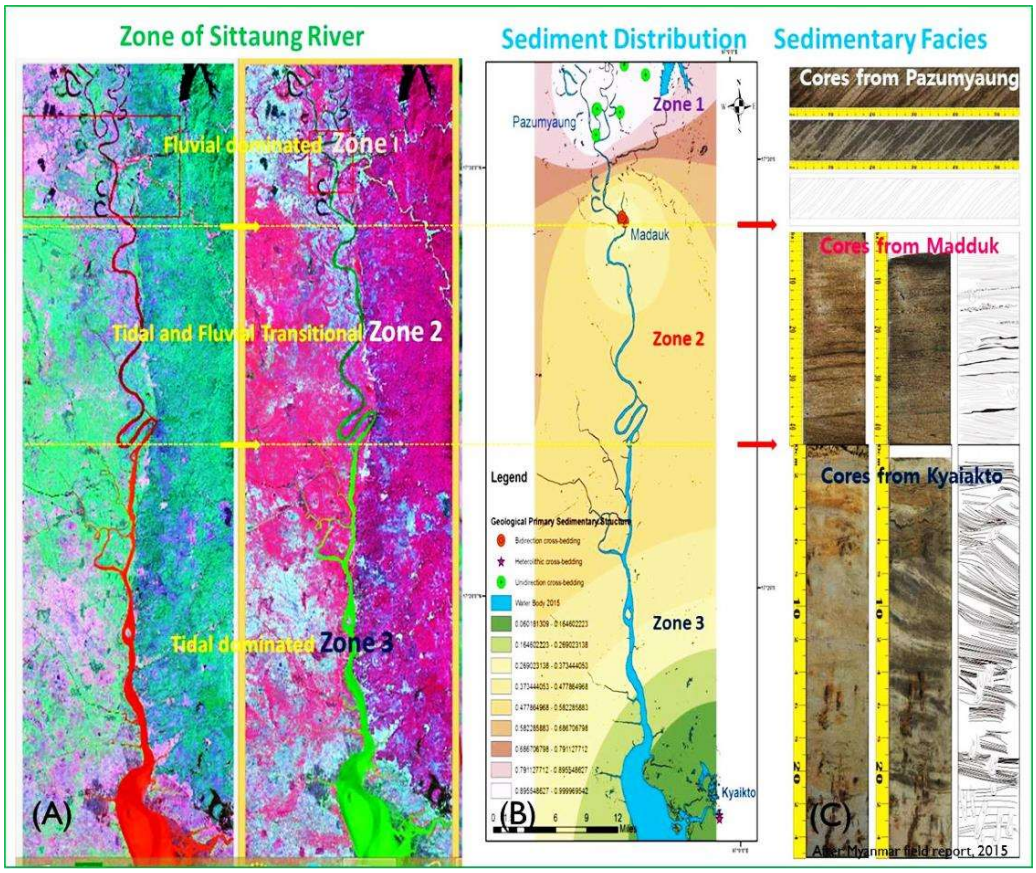


**Figure 3.** Three Zones of Sittaung River. **(A)**There are three morphological zones which are confirmed by Geospatial analysis of RS and Arc Map and geomorphological data in the field. In this case, the band combination of RGB, band 685 and band 654 of 132_48 N, 2015 Landsat image is suitable in River zones classification.**(B)** The interpolation of stream sediment distribution give the modified zone of sediment. **(C)** The primary sedimentary structures are cross-bedding that indicate the zone of river. The resulted three morphological zones are fluvial dominated Pazumyaung area, Zone 1, the tidal and fluvial transitional Madauk area, Zone 2 and the tidal dominated Kyaikto area, Zone 3, respectively.

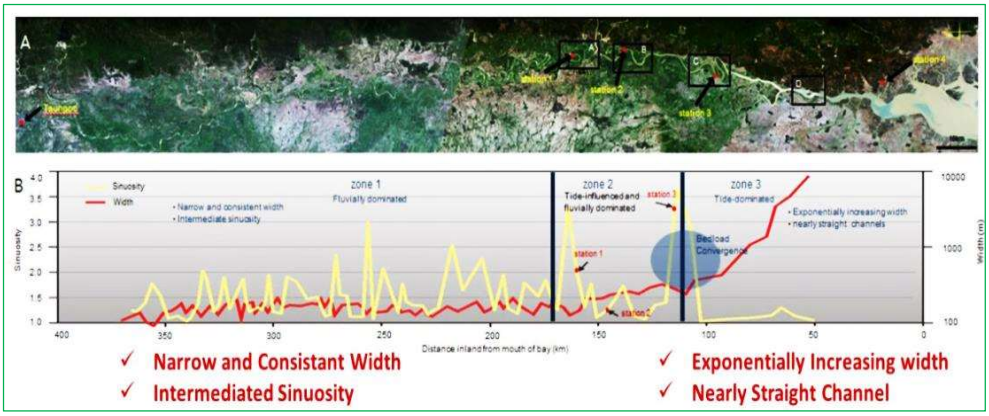


**Figure 4.** Sinuosity and Width of Sittaung River.

(A) Mosaics of satellite images showing Sittaung River in Myanmar with lengthy fluvial-tidal transition zone, approximately 150-180 km long from the mouth of estuarine embayment.

(B) Longitudinal distribution of channel sinuosity and width from the mouth of estuarine embayment to Taungoo. [After Myanmar Field Study Report (Feb. 6th to Feb. 12th, 2015)]

## Scroll bar pattern analysis

Scroll bar patterns of the channels were analyzed by satellite and drone images. In Pazumyaung area which is fluvial dominated and characterized by large scroll bars, the channel moved mainly by expansion. Madauk area is located in tide influenced and fluvial dominated area. The scroll bars show extension and downstream translation patterns. Downstream Kyaikto is located in the tide dominated area, where scroll bars are not extensively developed. Scroll bars show downstream accretion. See Figure (5)

The scroll bar patterns are classified into three patterns. The first scroll bar pattern of Pazumyaung area shows the expansion of scroll bar migration which is named as fluvial dominated zone. The second scroll bar pattern of Madauk area displays the extension and translation of scroll bar migration which is regarded as the tidal and fluvial transitional zone. The third scroll bar pattern of Kyaikto area is not the extensive accretion of scroll bar migration which is known as tidal dominated zone respectively. See Figure (6)

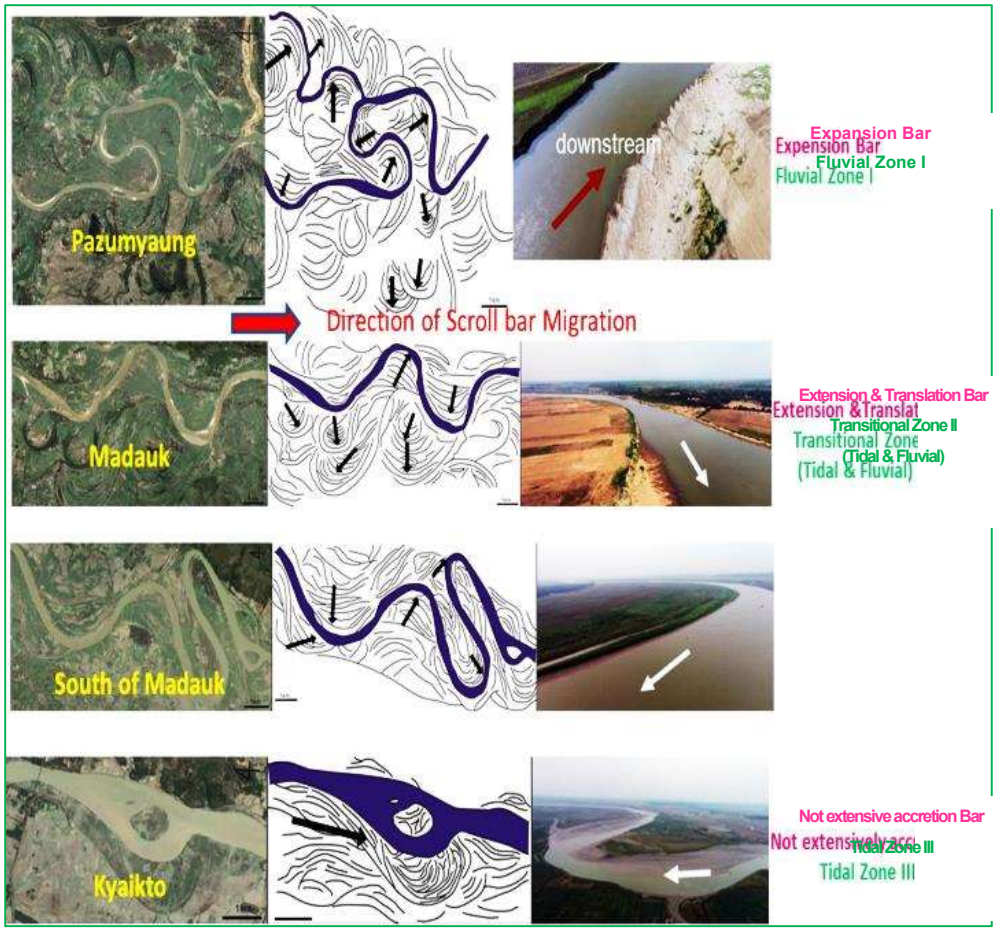


**Figure 5.** Scroll bar patterns of Sittaung River. [After Myanmar Field Study Report (Feb. 6th to Feb. 12th, 2015)]

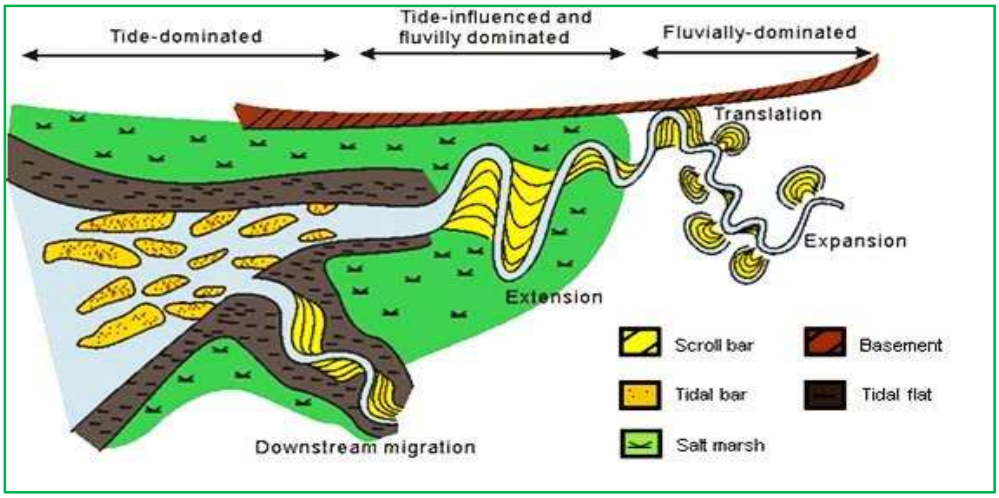


**Figure 6.** Schematic diagram showing major depositional components along the fluvial- tidal transition zone of Sittaung River.(Feb. 6th to Feb. 12th, 2015)

## Natural Changes of Sittaung River

### Geospatial Analysis

The main works of this project is based on the UTM maps and Landsat maps.The water body changes and coast line variation of Sittaung River are analyzed by using density slice on ENVI 4.7. Choosing the Band 6 is suitable for Density Slice. The Slice range is 6 to 27 Red. The Comparative studies of the Landsat image 132_48N, 2000, 2005, 2010, 2015 and UTM map 2000 give the water body area changes and variation of coast line of Sittaung River. The erosion and deposition sedimentary processes occurred more frequently in the three specified areas of Pazumyaung, Madauk and Kyaikto of Sittaung River which are designated as unstable coast line areas and flooding areas. See Figure (7).

The Natural Cross-Sectional Profiles of the river are determined based on the satellite image. The first profile line of Pazumyaung area displays the small width and depth of river and folded mountains with no tidal effect. The second profile of Madauk area shows the prominent width and depth of river and folded mountains which are tidal and fluvial transitional area. The third

profile line of Kyaikto area shows the very large width and depth of river and large flat plain which is tidal dominated zone. All of these geomorphological profiles explain that the river is gradually getting wider and deeper towards the river mouth depending on the tidal effect. See Figure (8).The images analysis of water body indicates that the river is gradually getting deeper and wider from 2000 to 2015.The lower part of Sittaung Delta area, Kyaikto and Belin was constructed as a large delta by sediments from the upper and middle parts of the river. See Figure (9).

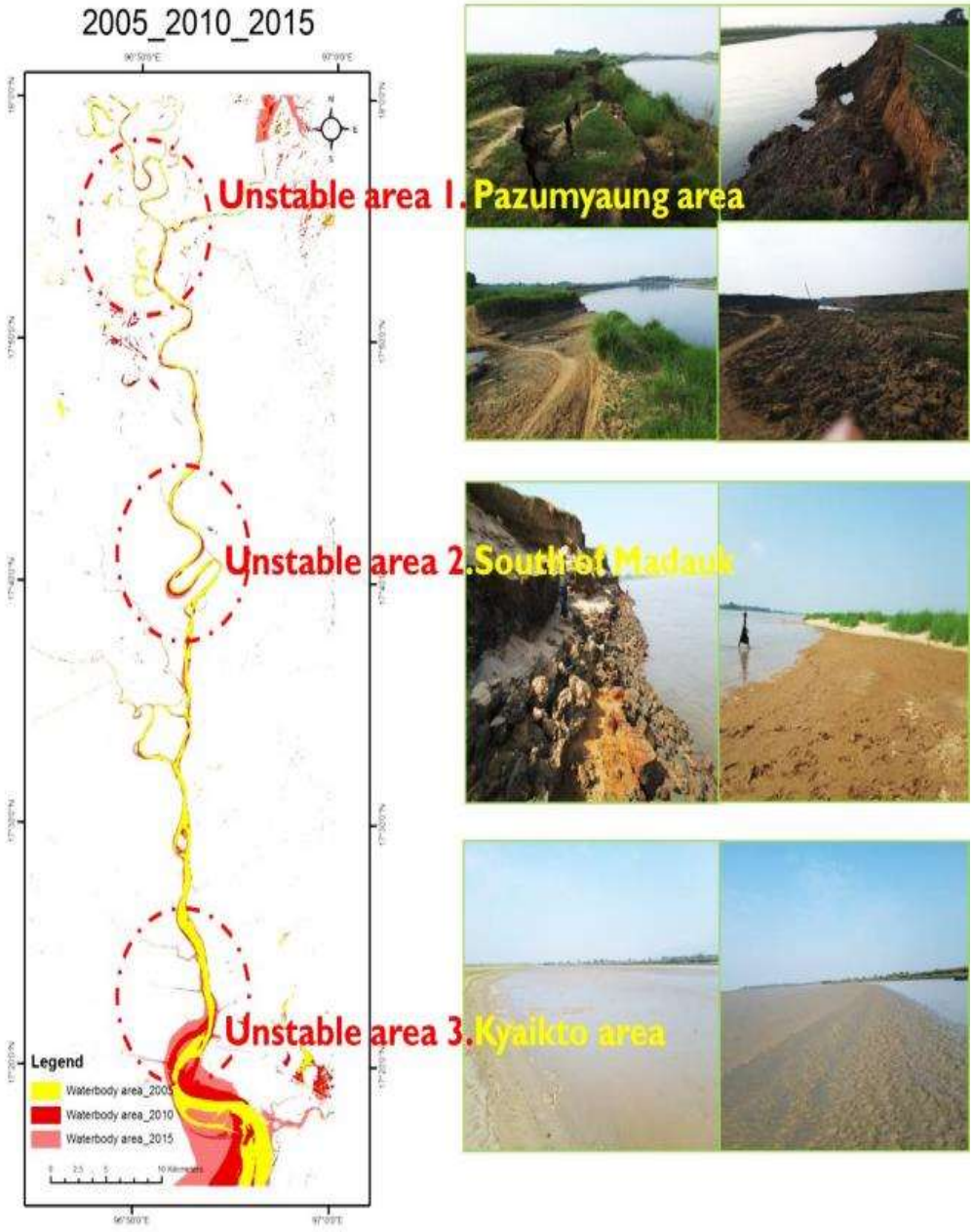


**Figure 7.** The Changes of Water Body area and Coast Line of Sittaung River in the Year of 2005 to 2015.

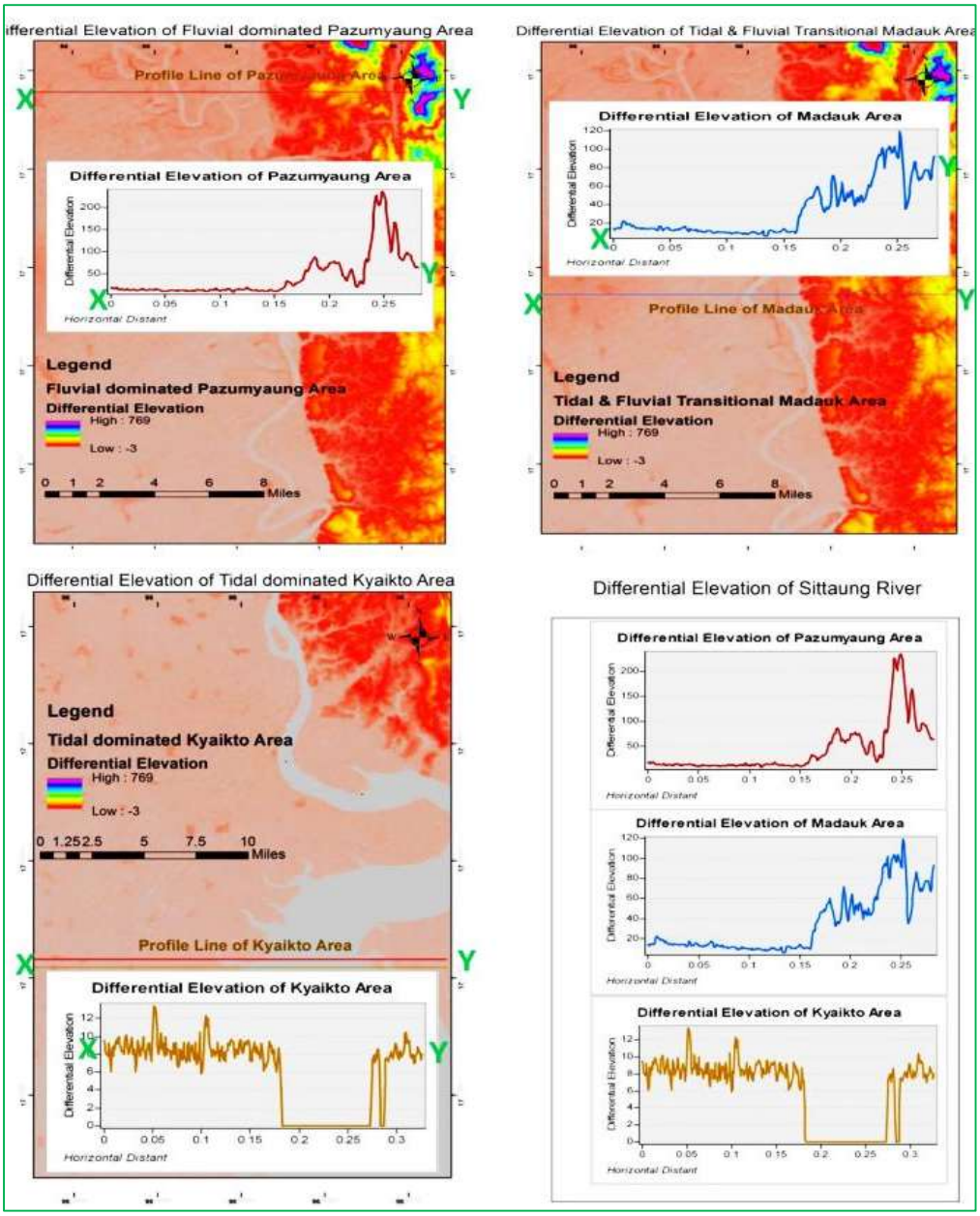


**Figure 8.** Differential Geomorphic Elevation of Sittaung River; width and depth of River is gradually increasing from fluvial dominated area to tidal dominated area.

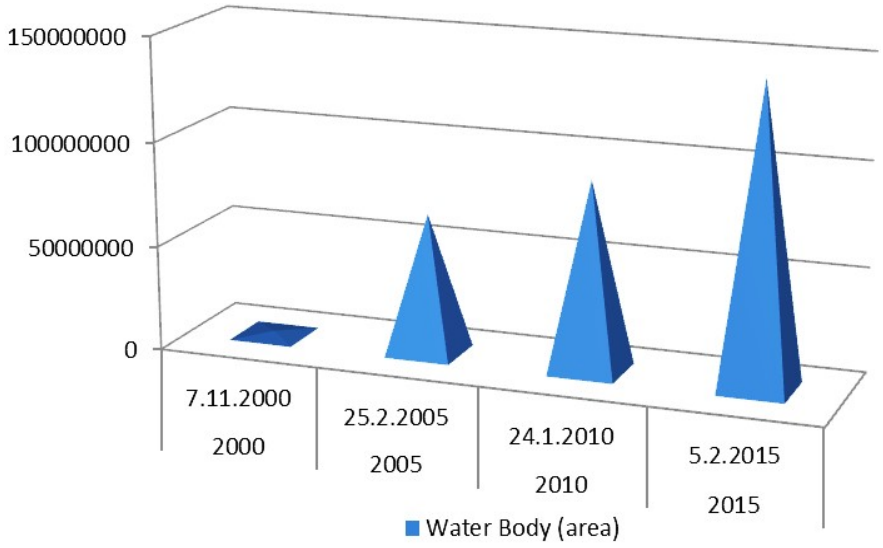


**Figure 9.** Histogram is showing the water body area of Sittaung River in the years of 2000 – 2005 – 2010 – 2015 by image interpretation. These water body changes indicate that the River is gradually getting deeper and wider from 2000 to 2015.

## Summary and Conclusions

### Geomorphological Characters and Zones of Sittaung River

The sedimentary facies (primary sedimentary structures), scroll bar patterns, sinuosity and width indicate the zones of Sittaung River as follows:

1. Pazumyaung area is fluvial dominated zone.
2. Madauk area is fluvial and tidal transitional zone.
3. Kyaikto area is tidal dominated zone.

### Natural Changes of the Sittaung River

1. Waterbody of Sittaung River is regularly increasing from fluvial area to the delta area of Kyaikto.
2. The Surface Sediments are gradually decreasing in size from fluvial area to the delta area of Kyaikto.

3. The length and width of the river is progressively increasing from fluvial area to the delta area of Kyaikto.
4. South of Madauk area and Kyakto areaare highly environmentally changed areas where natural disasters such as river flooding and flooding related environmental problems in Sittaung River and its basin are likely.

## Recommendation

From the environmental view, the best solution to minimize flood damage is floodplain regulation. In highly urban areas, however it will remain necessary to use physical barriers, reservoirs and channel works to protect existing development. Structural approaches of flood control include channelization, dams, retention ponds, reservoirs, levees, dikes and flood walls designed to keep out flood waters. Real-time monitoring of floods allow experts to forecast the arrival time and magnitude of the flood peak, and if necessary, issue early warnings. More public awareness programmes are needed to help people perceive the hazard of living in flood-prone area.

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