Geomorphological Changes of the Lower Ayeyawady River, Kyauk Ye – Zalun Reach, Ayeyawady Region

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Abstract

River channel changes, bank slope failure and flooding frequently occurred along the lower Ayeyawady River. The study area, Kyauk Ye – Zalun reach, is also strongly affected by the hydrodynamic process during raining season. Hinthada area, delta plain, is mud, silt and tide dominated system. The soil types of the area are silt, clay and sand. The largest landuse and landcover change is cropland to cropland occurred between 2000 and 2020. The notable river channel changes also occurred in 2000 to 2005 and 2015 to 2020. The channel bar area and channel width were predominantly changed during these episode. During 2015 to 2020, the river channel changes and bank failure notable increased along the Kyauk Ye, Theyo, Nga Pyaw Taw and Phaung Seik Villages.

Keywords: Hinthada, delta plain, soil types, landuse and landcover, channel changes

INTRODUCTION

Natural disasters related with river channel changes, bank slope failure and flooding have been occurred along the lower Ayeyawady River. The study area, Kyauk Ye-Zalun reach, also frequently affected the hazards related with the channel changes and slope failure mechanism. It is also located on Ayeyawady Delta plain, which is mud, silt and tide dominated delta and coverage area is about ~35,000 km^2 (Hedley et al., 2010). The research area extend to about 40 km from upper (Kyauk Ye Village) to lower (Zalun) reach. The largest channel width of this reach is about 10 km at the Duya Inn.

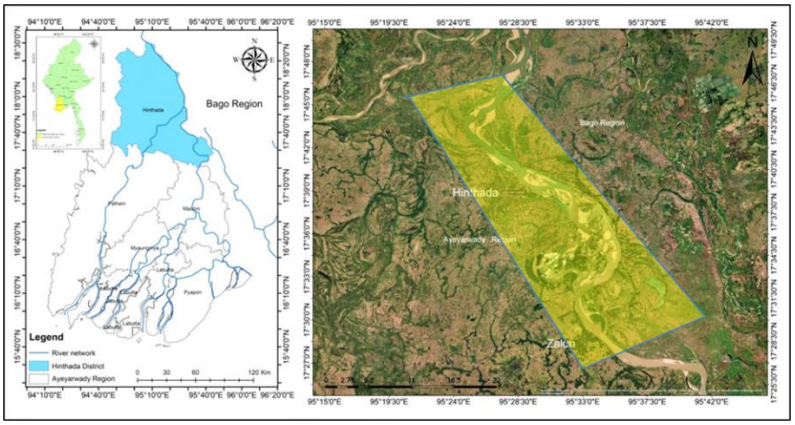

Figure 1. Location map of the lower Ayeyawady River, Kyauk Ye – Zalun Reach, Hinthada

Methodology

The research method mainly based on remote sensing and GIS techniques. Time series changes analysis were carried out by using satellite imagery. Google Earth Engine, ArcMap, Global Mapper, Surfer and Google Earth Pro software were used for landuse and landcover

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classification and annual channel changes mapping. Field investigation is also used for ground checking. The main limitation factor of this research is that the satellite images have cloud over in the rainy season. The bathymetric studies can't also proceed remote sensing method especially hydraulic and hydrological studies.

REGIONAL GEOLOGY

Ayeyawady Delta plain is mainly consisted of younger alluvium sediments. The sediment deposits and bed load are brought from upper course. Sand, silt and clay are the main bedrocks of the delta. There are a lot of crop lands on the alluvium plane. Channel bars along the river are sand and silt. Irrawaddy Formation is overlaid by recent soil deposits. The Formation is mainly composed of light grey to yellowish brown, medium to thick bedded, coarse-grained, gritty, and loosely consolidated sandstones with intercalated siltstones and light grey colored clay or mudstones (Figure 2).

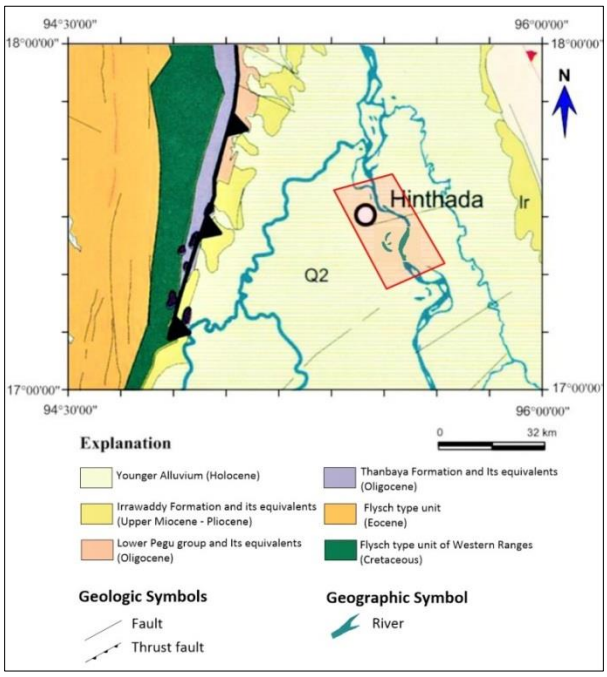

Figure 2. Regional geological map of the Hinthada area (MGS 2014)

GEOMORPHOLOGICAL CHANGES

River morphology is explained by channel patterns and channel forms (Xu Linjuan et.al (2018). Meander channel, the large sweeping curves in the middle and lower stage of a river, is formed by the combination of erosion and deposition. The channel is deeper in the pools and it has more energy, efficient and erosive power. The river channel of research area is also meander channel (Figure 3). There are the major changes of the river along the cut off bank and point bar area. A lot of villages are eroded and affected by bank failure.

Braided streams tend to occur in rivers with high sediment loads or coarse grain sizes, and tend to do in rivers with steeper slopes than typical rivers with straight or meandering channel patterns. The braiding and sinuosity index of the Kyauk Ye-Zalun reach is the highest during 2000 to 2005 (Figure 4).

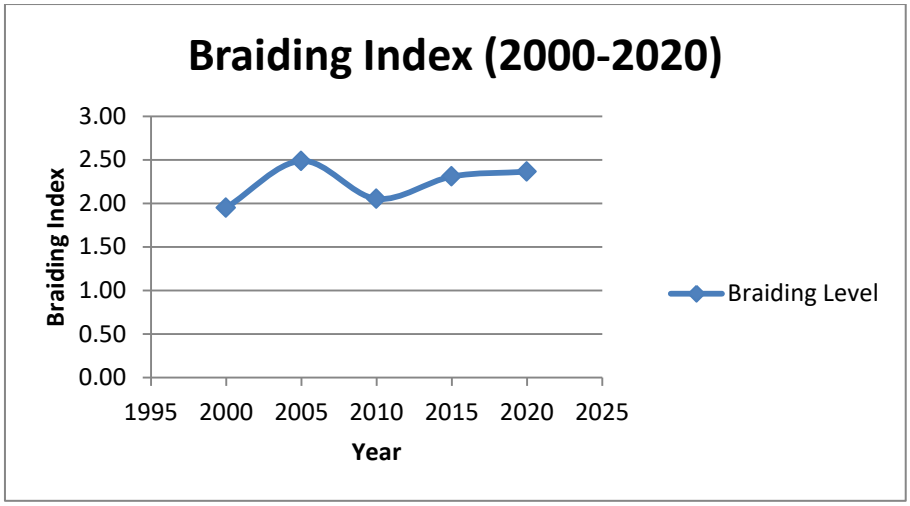

Figure 3. Braiding index of Kyauk Ye-Zalun reach (the highest level is during 2005 and channel expansion is the also highest in 2000-2005)

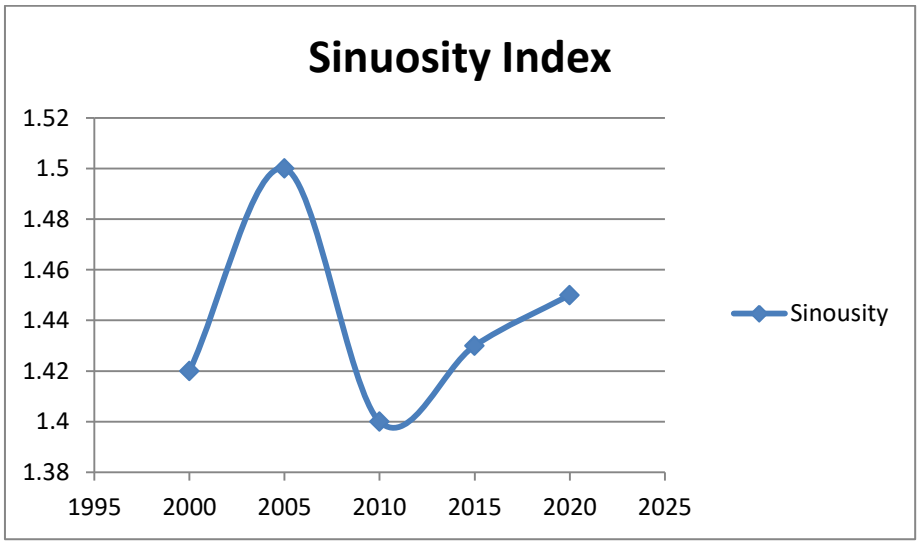

Figure 4. Sinousity index of study area (highest index in 2005)

Landuse and Landcover Changes

The landuse and landcover map of the area are shown in figure 6. According to this map, channel changes also caused the other landuse area changes (eg. settlement, sand bar, crop land).

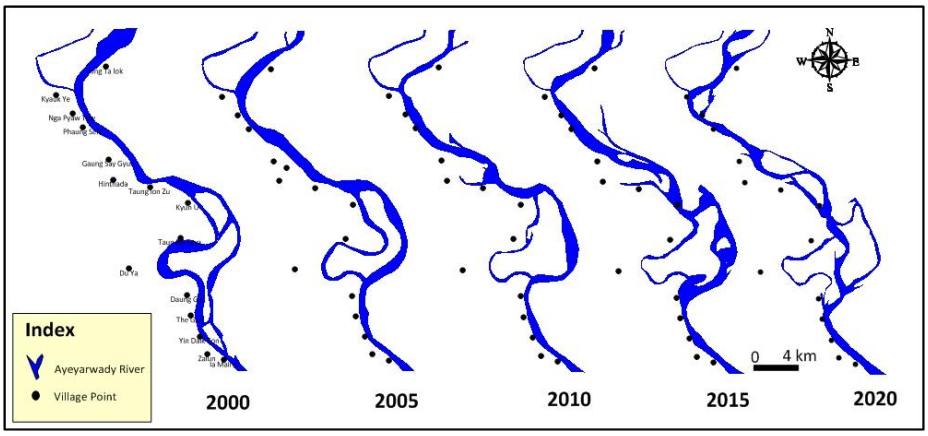

Figure 5. Channel area of Kyauk Ye – Zalun reach (without mid channel bars)

During the 2000-2020, the notable change of the area is cropland to cropland (about 42349 ha) (Figure 7). Settlement and cropland changed to water and sand dune that are major effects of river channel dynamic processes.

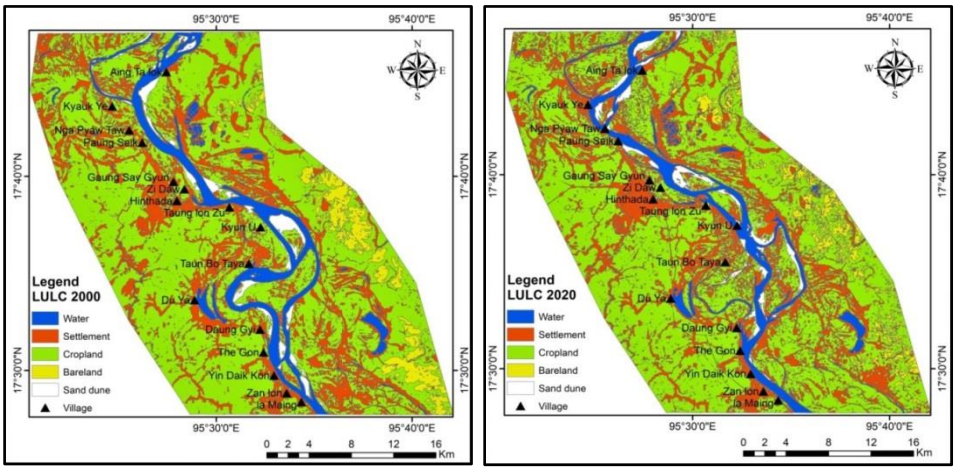

Figure 6. Landuse and landcover map of Hinthada Area (2000 and 2020)

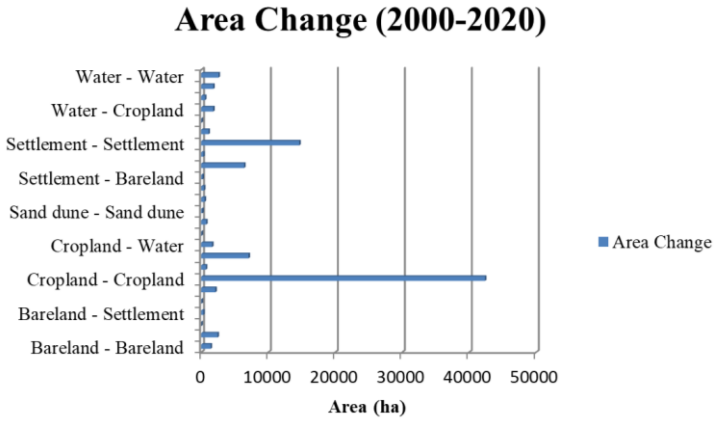

Figure 7. Notable area changes between 2000 and 2020 (cropland to crop land, settlement to settlement and settlement to cropland)

River Channel Changes

The channel of the Kyauk Ye to Zalun reach was expanded, contracted and adjusted between 2000 and 2020 (Figure 5). River platform channel changes in the last 20 years were

divided into four episodes (2000-2005, 2005 – 2010, 2010 – 2015 and 2015 – 2020). Between 2000 and 2005, the channel width and area increased about 335 m and 914 ha, respectively (Table - 1). This episode is the largest change of channel area. During 2005 to 2010, the channel area was slightly increased about 62 ha and width was also increased 148 m. In that time span, the smallest area changes happened.

Table 1. Ayeyawady River (Kyauk Ye – Zalun reach) channel characteristics (2000-2020)

Year	Channel Width (m)	Channel Area (ha)	Sinuosity
2000	2668	9920	1.42
2005	3023	10834	1.50
2010	3171	10896	1.40
2015	3303	11304	1.43
2020	3773	12139	1.45

Channel bar is the elevated region deposited by channel flow. Increasing channel bar area can cause river area expansion. In this reach, channel bar area increased about 1044 ha, 373 ha, 64 ha and 340 ha in 2000-2005, 2005-2010, 2010-2015 and 2015-2020, respectively (Table - 2). In general, increasing bar area is influenced by cutoff bank failure and deposition in pools (deep) and riffles (shallow).

Table 2. Changes in Ayeyawady River (Kyauk Ye - Zalun area)

Time Interval	2000-2005	2005-2010	2010-2015	2015-2020
Change in Channel Area (ha)	914	62	408	656
Change in Channel Bar Area (ha)	1044	373	64	340
Change in Channel Width (m)	355	148	132	470

Between 2000 and 2020, channel width increased about 1105 m, approximately. Channel area was expanded about 2219 ha. Mid-channel bar area increased about 1821 ha. Channel bar and island area increasing in 2000 to 2020 directly related with channel expansion in this reach.

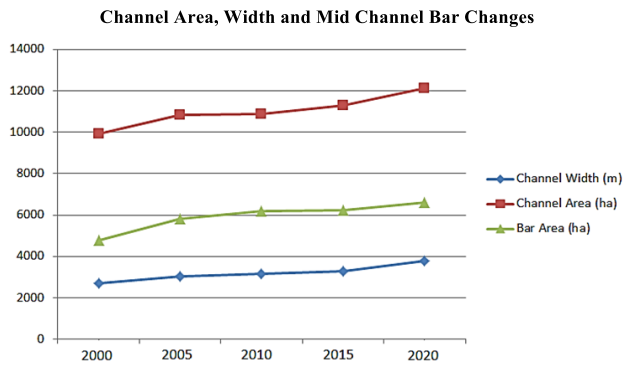

Figure 8. Correlation of the channel area, width and mid channel bar area

Channel Expansion

Channel widening will likely be more pronounced on the lower Hinthada-Danubyu reach than the upper Hinthada-Danubyu reach (Nay Win Oo, 2010). The largest expansion was about 914 ha between 2000 and 2005. In this episode, the mid channel bar was also increased about 1044 ha. Mid channel bar and channel width were also increased in this episode. This criterion indicated that the strong hydrodynamic process occurred in these years.

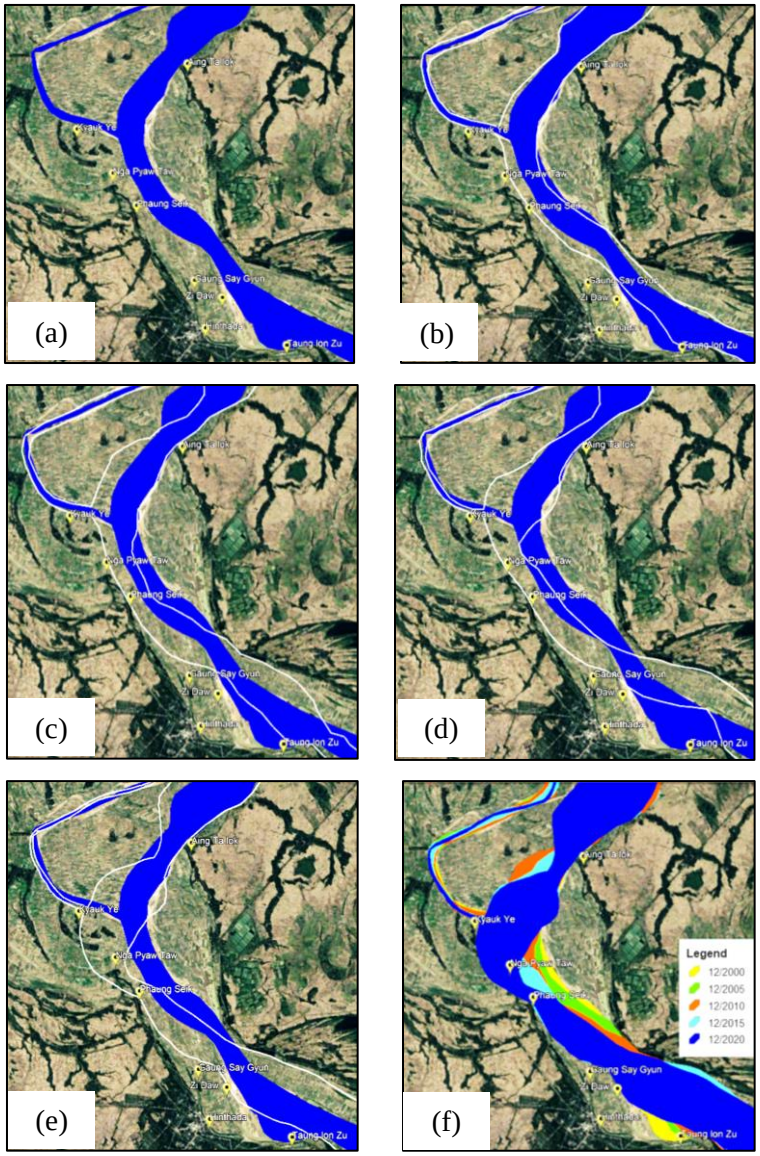

Figure 9. River channel changes along the upper part of study area, a) 2000, b) 2005, c) 2010, d) 2015, e) 2020 and f) total changes (light blue color of a,b,c,d and e is water body in 2000 and white polygon is channel changes)

Between 2015 and 2020, cut off bank failures and related hazards occurred along the Kyauk Ye to Zalun reach in every year. Between 2015 and 2020, the channel area, mid channel bar area and channel width were highly increased about 656 ha, 340 ha and 470 m, respectively.

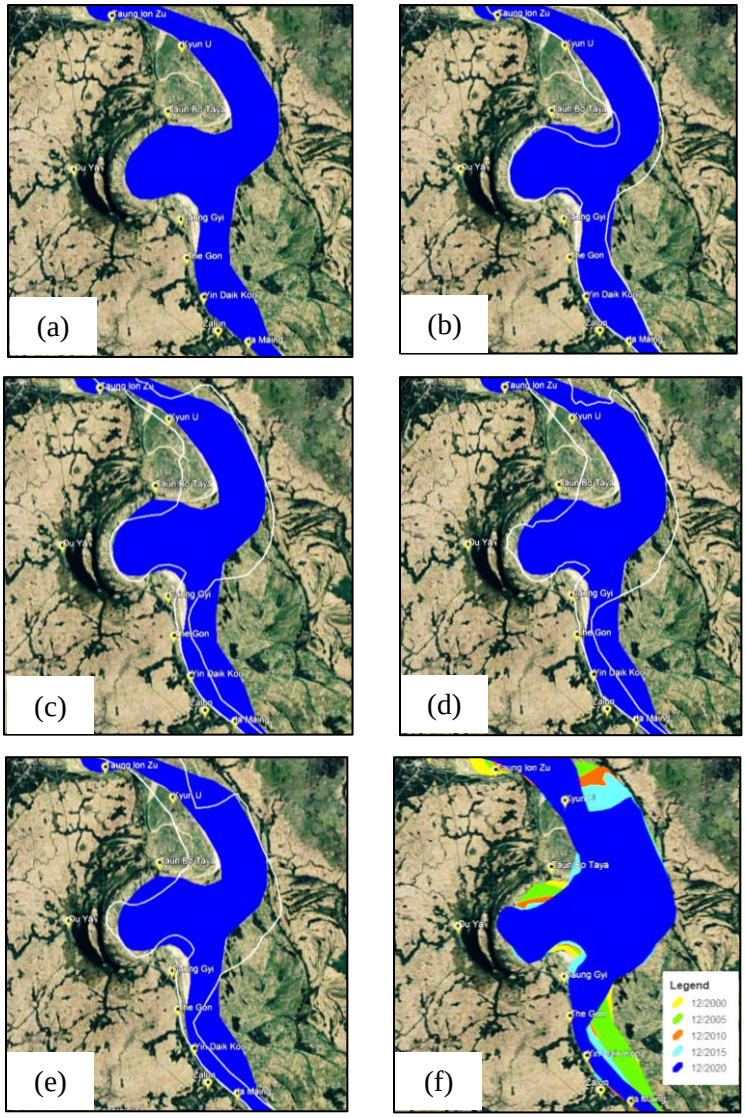

Figure 10. River channel changes along the lower part of study area, a) 2000, b) 2005, c) 2010, d) 2015, e) 2020 and f) total changes (light blue color of a,b,c,d and e is water body in 2000 and white polygon is channel changes)

Channel Contraction

The recovery from flood induced widening and in channel establishment of riparian plant species cause the channel narrowing (Friedman, 1996). In this area, recovery and lateral encroachment retaining wall were made along the urban area, Hinthada city. This caused channel contraction at that area but that overall area was slightly expanded in that year (2005-2010). The minimum expansion was 62 ha which occurred during 2005 and 2010 (Figure 9 and 10).

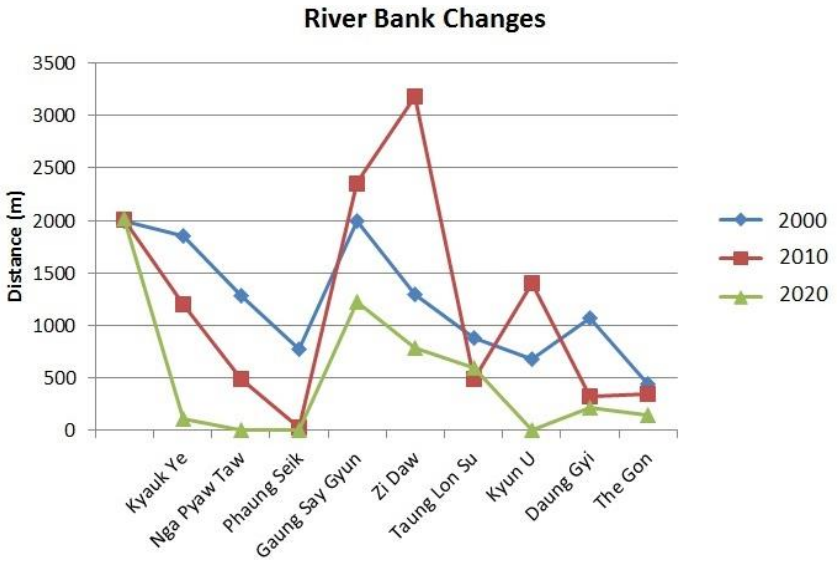

Figure 11. River bank changes in 2000, 2010 and 2020 (in 2020, the river banks of the Kyauk Ye, Nga Pyaw Taw, Phaung Seik, Daung Gyi are notibaly closed to the villages points)

RIVER BANK EROSION

The principal causes of stream bank erosion may be classed as geologic, climatic, vegetative, and hydraulic. These causes may act independently, but normally work in an interrelated manner. Direct human activities, such as channel confinement or realignment and damage to or removal of vegetation, are major factors in stream bank erosion (Kelly J. Klausmeyer, 2010).

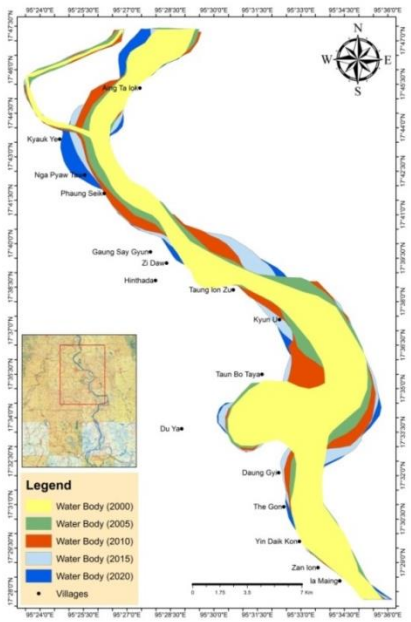

Figure 12. Time series changes along the Kyauk Ye – Zalun reach (water body are 2000 = 9920 ha, 2005 = 10834 ha, 2010 = 10896 ha, 2015 = 11304 ha and 2020 = 12139 ha)

The main factors of stream bank erosion (used in bank erosion potential index) are described as followed, adapted from Rosgen David L (Figure 13).

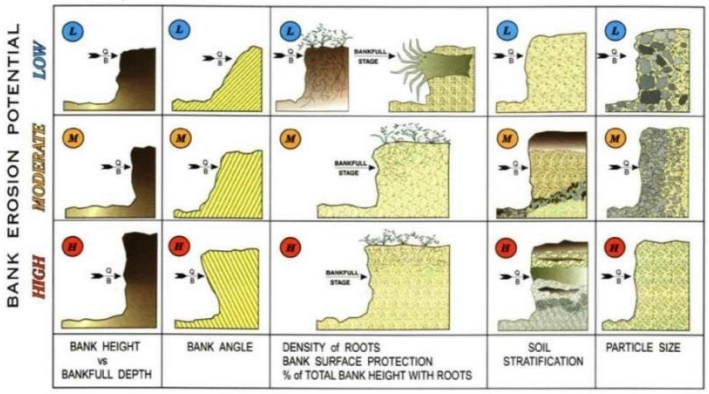

Figure 13. Stream bank erodibility factors (EFH Notice 210-WI-119)

The river bank erosion occurs when flowing water exerts a tractive force that exceeds the critical shear stress for that particular stream bank material. Hydraulic failure is generally characterized by a lack of vegetation, high boundary velocities, and no mass soil wasting at the toe of the slope.

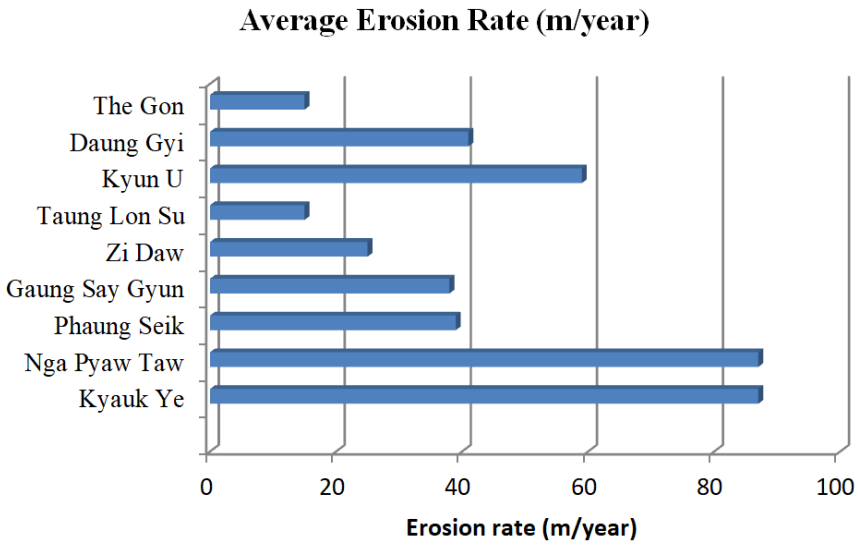

Figure 14. Average bank erosion rate of the some hazardous villages located along the western side of river

Kyauk Ye, Nga Pyaw Taw, Phaung Seik, Gaung Say Gyun, Zi Daw, Taung Lon Su, Kyun U, Daung Gyi and The Gon Villages are located along the western side of river. These villages are also situated on hazardous area where Nga Pyaw Taw, Phaung Seik and Kyun U Villages (village points in 2000) disappeared during 2000 to 2020 (Figure 11). The highest erosion rate of these areas is about 87 m/year in Kyauk Ye and Nga Pyaw Taw area and lowest erosion rate is about 15 m/year along the Taung Lon Su and The Gon Villages. (Figure 12 and 14). The erosion rates of other villages are slow but high variable area.

CONCLUSION

The river channel of the research area was eroded by strong hydrodynamic process. The area, delta plain, is mud and silt dominated delta and most of the river bank materials are clay, silt and sand. The sinousity and braided index of the river reached highest level, about 1.5 and 2.5, respectively in 2005. Landuse and landcover analysis were indicated that the largest

change is cropland to cropland about 42349 ha during 2000 to 2020. Other notable changes are settlement to settlement and settlement to cropland area. The channel area and width were increased 914 ha and 335 m during 2000 to 2005. The largest channel changes was also occurred in this episode (2000 to 2005). The increasing channel bar area caused the channel expansion. Some of the villages were disappeared between 2000 and 2020 because of river bank erosion. The highest erosion rate of this reach is about 87 m/year along the Kyauk Ye and Nga Pyaw Taw area and lowest rate is about 15 m/year. The river bank stability methods need to maintain the river bank slope failure along the research area.

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